ERDC/CHL TR-01-30

Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Desktop Study for Shoaling Prediction in Corpus Christi Navigation Channel, Texas

Trimbak M. Parchure, Soraya Sarruff, and Ben Brown

November 2001

20020403 090

Approved for public release; distribution is unlimited.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

PRINTED ON RECYCLED PAPER

ERDC/CHL TR-01-30
November 2001

Desktop Study for Shoaling Prediction in Corpus Christi Navigation Channel, Texas

by Trimbak M. Parchure, Soraya Sarruff, Ben Brown

Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Engineer District, Galveston
P.O. Box 1229
Galveston, TX 77553-1229

Contents

Preface

A desktop study was conducted for estimation of siltation in the Corpus Christi Navigation Channel, TX, resulting from its widening and deepening. The study was conducted at the Coastal and Hydraulics Laboratory (CHL) of the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, during 1999-2000. The U.S. Army Engineer District, Galveston, provided funding for this study. Dr. Trimbak M. Parchure, research hydraulic engineer, was the principal investigator for the project. Dr. Parchure prepared this report jointly with Ms. Soraya Sarruff and Mr. Ben Brown of CHL. The work was conducted under general supervision of Dr. Robert T. McAdory, Chief, Tidal Hydraulics Branch, and Dr. James R. Houston, former Director, CHL. During the preparation and publication of this report, Mr. Thomas W. Richardson was Acting Director, CHL.

The report was published by CHL. CHL was formed in October 1996 with the merger of the Coastal Engineering Research Center and the Hydraulics Laboratory. The Waterways Experiment Station (WES) has now become part of ERDC.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

1 Introduction

Background

The U.S. Army Engineer District, Galveston, has proposed widening and deepening the Corpus Christi navigation channel. The District considered the following options:

a. Deepen the channel to 15.85 m (52 ft) from the Gulf of Mexico to Viola Turning Basin in Inner Harbor including widening across Corpus Christi Bay to 152.4 m (500 ft.)

b. Deepen the channel to 15.2 m (50 ft) from the Gulf of Mexico to Viola Turning Basin in Inner Harbor including widening across Corpus Christi Bay to 152.4 m (500 ft.)

c. Widen only the Bay reach of the Corpus Christi ship channel from 121.9 to 152.4 m (400 to 500 ft.)

d. Barge lanes with ship channel deepening to 15.85 m (52 ft) and widening to 152.4 m (500 ft.). Barge lanes at 4.27 m (14 ft) deep and 45.7 m (150 ft) wide on both sides of ship channel.

The District requested the U.S. Army Engineer Research and Development Center (ERDC), to conduct a desktop study on estimation of future shoaling in the deepened Corpus Christi ship channel for the first option. The effect of adjacent disposal sites on channel shoaling needed to be included to verify whether the amount of sediment from the disposal sites returning to the ship channel is small.

Objective

The objectives of the desktop study were:

a. To estimate the shoaling rate in the Corpus Christi channel resulting from deepening the existing channel from 13.71 m (45 ft) to 15.85 m (52 ft).

b. To estimate the extent of sediment from the nearby disposal sites getting into the dredged channel.

Approach and Scope of Work

The District needed an approximate answer requiring less time and cost. Hence the following approach and scope of work for a desktop study was proposed:

a. Field data already available will be analyzed, and the results of analyses will be used. These data consist of velocity data, historic shoaling/dredging records, and surveys available from the Corpus Christi Area Office. Attempts will be made to obtain additional data from other sources and results of their analyses will be used.

b. Results of analyses done on bed sediment and suspended sediment samples collected by ERDC-CHL will be used.

c. Assumptions on the spatial and temporal variation in the values of relevant parameters will be made.

d. Quick runs will be conducted on the existing numerical hydrodynamic model for a few selected conditions to determine the effect of deepening the channel on the currents in the area of interest.

e. The wind and current climate of the area will be taken into account

f. A quantitative estimate will be provided on future shoaling in the navigation channel based on the field and model data analysis. The effect of deposition of dredged material on the disposal sites near the navigation channel will be assessed.

2 Field Data

Data Supplied by Galveston District

The Galveston District supplied survey data, channel cross sections, dredging quantities, and project layout maps.

Data from other Sources

Data received from the Conrad Blucher Institute consisted of the following items:

a. Draft data report dated January 14, 2000.[1]

b. CD containing data on various parameters.

c. Results of field data on measurement of total suspended solids.

The field data were collected at five locations, which are shown in Figure 1. Locations 1, 4, and 5 were in the Corpus Christi Bay, location 2 was at Titanic, and location 3 was at Andrea Doria. Details such as the coordinates of data collection stations, sensors used and the depth of sensors are given in Table 1. The parameters recorded at each station and the duration of data collection are given in Table 2.

Field Data Collected by ERDC-CHL

The ERDC-CHL field team collected the following field data:

a. A total of 95 surface bed sediment samples were collected at widely scattered locations within the Corpus Christi ship channel and over the dredged material placement areas close to the ship channel.

b. Water samples at local middepth were collected at all locations where bed sediment samples were collected.

[1] Conrad Blucher Institute for Surveying and Science. (2000). "Monitoring and analysis of sediment transport and hydrodynamics at dredged material sites in Corpus Christi Bay, TX," Draft data report. Texas A&M University, Corpus Christi, TX.

c. Water samples were also collected every 30 min at one location by anchoring a boat. These samples were collected at three depths within the local water depth over duration of about 14 hr.

3 Analysis of Field Data

Sections, Reaches, and Zones

A location map of the study area is shown in Figure 2. The Corpus Christi navigation channel is about 56.3 km (35 miles) long from the ocean to the harbor. The straight portion is located within the Corpus Christi Bay, where it is exposed to wind and waves. The entrance channel outside the two jetties is also exposed to wind and waves. The other parts of the channel have partial shelter offered by land and are less exposed to wind and wave action. For the convenience of the present study, 181 sections marked the entire length of the navigation channel. A segment of the channel between consecutive sections is denoted as reach. Several reaches together form a zone. The navigation channel has been divided into seven zones with a label for each as shown in Figure 3 and Table 3. Correlation between the District notation and the sections, reaches, and zones is given in Table 4.

Tides and Wind

The principal variation in tides in the Gulf of Mexico is caused by the changing declination of the moon. Diurnal tides occur at maximum declinations whereas semidiurnal and mixed tides occur when the moon is on the equator. The monthly spring tidal range at Aransas Pass varies from 0.64 to 0.85 m (2.1 to 2.8 ft) and the neap tidal range varies from 0.0 to 0.43 m (0.0 to 1.4 ft.). The diurnal tides have larger ranges 0.55 to 0.85 m (1.8 to 2.8 ft) than semidiurnal tides 0.24 to 0.43 m (0.8 to 1.4 ft). A fifteen-day predicted tidal variation at Aransas Pass is shown in Figure 4. Behrens, Watson, and Mason (1977) have reported that the tidal ranges and tidal water levels in this area are not in phase. Maximum water levels occur in October, April, and May, when the strongest onshore winds generally occur. Minimum water levels occur in January and February when the strong offshore winds predominate.

Comparison of observed tides with predicted tides reveals differences, which are attributed to the significant effect of local wind on tidal levels and currents. A correlation of onshore wind and tidal water levels at Corpus Christi is shown in Figure 5. Tidal ranges as well as mean water levels have an annual cycle of two highs and two lows.

Winds in the Corpus Christi area are strongly bimodal. The Northern Hemisphere Trade Wind System produces northeasterly wind, which has a strong onshore component and a moderate longshore component towards northeast. The southeasterly winds predominate during March or April through August or September. North-northeasterly winds result from the anticyclonic circulation of cold, high pressure Arctic and Pacific air masses. These predominate from September or October through February or March. These winds have a strong to weak offshore component and a moderate longshore component towards southwest. The high-pressure cells are preceded by low-pressure troughs or fronts, which draw air from both directions. Thus, as a norther approaches the coast, strong onshore winds blowing into the trough build up until the front passes and are rapidly replaced by equally strong or stronger offshore winds.

Watson and Behrens (1976) have prepared wind rose diagrams based on observed data for one year (July 1972 to June 1973). These are shown in Figure 6. Predominant wind directions in each month are listed in Table 5.

Conrad Blucher Institute has one of their several sites located at a station called Bob Hall Pier (Figure 7) where data on winds and tides are regularly observed. These data are available over the Internet. ERDC-CHL analyzed these data for a period of 1 year from January to December 1998. The wind speed and wind directions are shown in Figure 8. Seawater levels are shown in Figure 9. Predominance of southeast and north wind directions is seen from Figure 8 and higher water levels during September – October are seen from Figure 9.

Bed Sediment Samples

A total of 95 surface sediment samples were collected along the navigation channel and from the sediment placement areas. Locations of collection are given in Table 6. All the locations are shown in Figure 10.

The bed samples were analyzed in the ERDC laboratory for the following:

a. Particle size distribution was determined for all samples after removing organic matter.

b. Bulk density and sediment settling properties were determined for selected samples.

c. Total organic contents and total shell contents were determined for selected samples.

Results of particle size distribution of surface sediment samples collected in the navigation channel are given in Table 7. Results for the samples collected over placement areas are given in Table 8. These results are given in the form of percentage fraction of sand and silt plus clay. All the samples had a substantial percentage of shell fragments. The large-size pieces of shell were removed to the extent possible before separating sand from silt plus clay by using wet sieving process. The shell fragments ranged from about 2 percent to 30 percent.

Bulk density of selected samples was measured using Pycnometer bottles. The results are given in Table 9. Loss on ignition results on selected four samples from Zone 2 of the navigation channel are given in Table 10. Loss on ignition represents the percentage of organic matter in a sample.

The following observations are made on the results of analysis of bed samples:

a. All samples obtained from Zone 2 of the navigation channel had more than 90 percent sediment consisting of silt plus clay.

b. All samples obtained from Zones 3, 4, and 5 of the navigation channel contained more than 90 percent of sand (except samples 89 and 93, which had 37 and 74 percent of sand respectively).

c. Bulk density of bed samples collected from the navigation channel varied from 1.2 to 1.4 g/cu cm whereas bulk density of bed samples obtained from placement areas varied from 1.7 to 1.92 g/cu cm.

d. The organic matter in samples collected from Zone 2 of the navigation channel ranged from 5.41 to 10.16 percent, which is adequate for influencing behavior of fine sediment fraction in these sediments.

Water Samples

The salinity of gulf water generally ranges between 30 and 35 ppt. The Corpus Christi Bay water salinity range is much greater and highly dependent upon local weather conditions. Hypersaline (35 to 40 ppt) water may occur during drought periods, whereas close to freshwater (less than 10 ppt) salinity may occur following periods of high rainfall. Localized large salinity differences affect the vertical velocity distribution, increasing flood velocities at the bottom, resulting in movement of bottom sediment.

Conrad Blucher Institute collected data on Total Suspended Solids (TSS) at 268 locations. The magnitudes of TSS vary mostly from 10 to 40 mg/L with occasional high values reaching up to 110 mg/L.

ERDC-CHL collected water samples in August 2000 at the same locations where bed samples were collected. The locations are shown in Figure 10. All water samples were analyzed for determining salinity and total suspended matter by weight. The results of samples collected in navigation channel are given in Table 11. Results of samples collected over sediment placement areas are given in Table 12. The last column in these tables gives the channel zone in which these samples were taken. It may be noted that majority of the samples (from location 1 to location 78) were taken within Zone 2, which is the open bay channel zone.

In addition, water samples were also taken at a single station (station +750, shown in Figure 10, sheet 4 of 7) over a tidal cycle. This station was located between the bed sample locations 42 and 43. These samples were taken at three

depths over vertical, approximately at 1 hr interval. The results are given in Table 13.

The following observations were made form the results of analysis of water samples:

a. Salinity of all the samples was close to 39 ppt. This is higher than normal salinity of ocean, which is close to 35 ppt. The reason for higher salinity is low rainfall during the preceding year. As mentioned earlier in this section, past data have indicated that salinity of Corpus Christi is sensitive to local freshwater inputs or deficits.

b. No vertical variation in salinity was recorded during the present observations.

c. In Zones 2, 3, 4, and 5 the concentration of suspended matter ranged from 19 to 88 mg/L. The predominant variation was from about 20 mg/L to 40 mg/L. The suspension concentration is highly dependent on the local conditions of tidal current, wind, and wind-induced waves. Low values such as these may be a result of low energy site conditions at the time of data collection.

d. Strong vertical variation in suspension concentration was observed. While values close to water surface ranged form 13 to 38 mg/L, the near-bottom values ranged from 31 to 730 mg/L.

e. The concentration of total suspended matter over placement areas ranged from 11 to 39 mg/L. The placement areas predominantly have coarse sediment in the sand range. This sediment does not remain in suspension under low energy conditions and settles down fast even after getting in suspension temporarily. The amount of sediment in the silt and clay in the placement areas is very small. Hence, the concentration of suspended sediment is also small.

4 Analysis of Dredging Data

Dredging Quantities

The Galveston District supplied historical dredging records for different reaches of the navigation channel. The dredging quantities in the District's records were listed beginning with the channel starting from the ocean end. In the present study the navigation channel is divided into seven zones starting from the harbor end. Hence, the District data were reformatted into 180 sections and seven zones for the channel starting from the harbor end. The quantities are given in Table 13 and the plots are given in Appendix A. Analysis of cross sections of the Corpus Christi navigation channel is given in Appendix B.

Annual quantities of dredging along with the average dredging assuming a 20-year period are shown graphically in Figure 11. Large amount of dredging required during the year 1982 was due to shoaling in the navigation channel caused by hurricanes. Another large dredging event noticed during 1985 on this figure was due to capital dredging undertaken for deepening the navigation channel from 12.2 to 13.7 m (40 to 45 ft.) The average dredging rate was about 1.68 million cu m (2.2 million cu yd) per year. A summary of dredging quantities is given in Table 16. The percentages of total dredging in each zone are given in the following tabulation:

Zone	Percentage
1	14.93
2	50.12
3	05.32
4	02.67
5	00.00
6	01.53
7	25.42

Shoaling Estimates

The U.S. Army Corps of Engineers Committee on Tidal Hydraulics (1965) performed a study of a sedimentation problem. This study concentrated on the effects of industrial withdrawals and discharges and on the chloride concentrations in the harbor. Hence, it is not relevant in the context of the present study. Smith, McAnally, and Teeter (1987) conducted shoaling investigations of the Inner Harbor. They concluded that the shoaling problem at the entrance to the harbor and in the turning basin is caused by the high concentration of suspended material in the channel. The sediment is transported along the channel and is drawn into the harbor by a

strong density current. Low bottom velocities and high settling rates allow the sediment to settle and consolidate in the area near the entrance to the harbor.

Average dredging interval in various reaches of the channel is shown in Table 15. It is seen from this table that areas that require frequent dredging are the entrance to the harbor area, the open bay channel, and the outer channel outside the jetties.

The best way to estimate changes in siltation rates in navigation channels is the application of a verified sediment transport and shoaling/erosion numerical model. This is particularly true in systems such as La Quinta, which involves new construction. Desktop studies such as the one presented in this report, however, can provide a cost-effective alternative for estimating these rates.

Universally applicable formulas or methods are not available in books or published literature for estimating change in siltation rates in navigation channels as a result of extension, widening, or deepening. However, such estimates have been made in the past on some projects based on experience, field data, and understanding of site conditions.

An increase in length, width, and depth of a navigation channel often results in an increased quantity of siltation and hence, an increased cost/frequency in dredging. Data on dredging quantities with the predeepening and prewidening conditions are useful in the prediction of future quantities. An accepted practice consists of applying a multiplication factor, greater than 1.0, to the dredging quantities for the predeepening and prewidening conditions. The following parameters are taken into account while selecting this factor, which is very much site-specific and may vary for different locations of the same project:

a. Relative change in length, depth and width

b. Properties of bed material

c. Geometry of navigation channel

d. Properties of suspended material

e. Magnitudes of suspended sediment concentration

f. Change in the magnitude and direction of existing current conditions resulting from changes in channel dimensions

g. Wind and wave climate at site

h. Nature and location of sediment source

Shoaling in the Corpus Christi Navigation Channel will increase after it is deepened to 15.2 m (52 ft) from the present depth of 13.7 m (45 ft) and widened over the Bay area from the present 122 m (400 ft) to 152.4 m (500 ft). Based on the considerations previously described, estimated average annual shoaling rates with the deepened and widened channel are given in Table 16.

The estimated rates are as follows:

Zone	Estimated Average Annual Shoaling (cu m)	(cu yd)
1	305,820	400,000
2	1,300,000	1,700,000
3	114,682	150,000
4	76,455	100,000
5	0	0
6	38,227	50,000
7	535,186	700,000
Total	2,370,370	3,100,000

Placement Areas

Areas for placement of dredged material are located on the north and south sides of the navigation channel within the bay area (Figures 12 and 13). In other parts of the channel they consist of confined disposal areas on land. Since the placement areas in the bay are close to the navigation channel and they do not have any armor protection, the sediment placed over them has a potential to return to the dredged channel. The sediment in the navigation channel, which is dredged and deposited on the placement areas, consists of 90 percent silt plus clay. However, particle size analysis of samples collected from the placement areas shows a complete absence of the silt and clay component. The material consists of a substantial quantity of shell fragments and sand. It is estimated that 90 percent of the sediment deposited over the placement areas is eventually washed away. The water depth over these areas is on the order of 2.13 m to 2.44 m (7 to 8 ft.) Wind-induced waves over these shallow areas bring the sediment in suspension, which is then carried away by the tidal and wave-induced currents.

Between the two predominant wind directions (north and southeast), wind from the southeast direction is more prevalent. Hence, more sediment will move northward. While the currents within the navigation channel are parallel to the channel, the wind-induced currents have a direction across the channel. Hence, they result in depositing sediment in the channel. While the sediment from the placement areas on the north side of channel will be carried away from the channel, the sediment from the south placement areas will travel towards the channel and deposit within the channel due to low energy conditions offered by the wider and deeper channel. During wind from the north, the situation reverses. It is estimated that 60 percent of the sediment is carried away from the channel and 40 percent is carried towards the channel. Since the navigation channel acts like a sediment trap for both wind directions, it is estimated that it traps 80 percent of the sediment crossing the channel in either direction. Thus it is estimated that 30 percent of the sediment deposited over the placement areas finds its way back to the navigation channel.

5 Numerical Model Results

Numerical Model

A vertically averaged two-dimensional numerical model of the area was already available at ERDC-CHL. This model was previously used for the Texas Water Development Board for conducting the salinity study of Corpus Christi Bay and surrounding area. Modifications were made to this model for increasing resolution within the navigation channel and other areas. The model was validated earlier as described in the Memorandum For Record (MFR) dated 20 July 2000 sent to the Galveston District.[1] The area included and model grid are shown in Figure 14. The bathymetry of the study area is shown in Figure 15.

It was clear from the site conditions that tides and winds have a strong combined frequency of occurrence. Data on both these parameters were analyzed for selecting appropriate combination of the two parameters. Conditions selected for running the numerical model are shown in Figures 16 and 17. Observed June tides were associated with Southeast winds whereas October tides were associated with north wind.

The base condition on the model consisted of 1999 bathymetry with the navigation channel at 13.7-m (45-ft) depth. Data on flow pattern, current velocity, and water level were obtained by running the model with and without wind. The model was then run for the plan condition by simulating dredging of the navigation channel to 15.2-m (52-ft) depth and widening of the Corpus Christi Bay Channel to 152.4 m (500 ft). Conditions used for running the numerical model are given in Table 17.

Velocities from Numerical Model

Velocity data from the model were obtained at 30 gage locations, which were selected at 10 places along the length of the navigation channel. Locations of gages are given in Table 18 and they are shown on Figure 18. Each location had three gages, one within the channel and one each on the north and south sides of the channel. Reach locations and corresponding gages are shown in Table 19. The model was run for an equivalent field duration of five days. Allowing time for initial spinup and stabilization, data from 69.0 to 96.5 hr were extracted for

[1] Smith, T. M., McAnally, W. H., and Teeter, A. M. (2000). "Validation of hydrodynamic model," Memorandum For Record, CEERD-HE-TE (1110-2-1403b), July 20, 2000.

analysis. The portions of June and October tides for this duration are given in Figures 19 and 20 respectively. The first set of data (Appendix C) were obtained for assessing the effect of wind and the second set (Appendix D) was obtained for assessing the effect of deepening and widening.

Flow patterns obtained from the model for the flood and ebb stages of tide are shown in Figures 21 through 26. The flow pattern reported by Powell, Matsumoto, and Longley (1997) is shown in Figure 27. Average velocities along the center line of the channel have been plotted in Figures 28 through 31 for comparing the effect of wind and the effect of modifying the channel on current velocities.

The following observations were made from the velocity data:

a. Current velocity in Zone 1 is very small, on the order of 0.0046 to 0.0061 m/s (0.015 ft/s to 0.02 ft/s.). In spite of its being sheltered by the surrounding land, wind from the southeast as well as wind from north caused significant relative increase in current velocity. However, the absolute magnitudes were less than 0.009 m/s (0.03 ft/s.)

b. Current velocity increases as we move towards the eastern end of the bay channel. Maximum velocity on the order of 0.91 m/s (3 ft/s) occurs within the two jetties at the eastern part of the navigation channel.

c. Channel deepening and widening slightly increase peak velocities along the channel, thus indicating a marginal increase in tidal influx. This would translate into a marginal increase in the sediment input from the ocean to the channel.

6 Discussion and Conclusions

Discussion

We had proposed to use the historical dredging data and information on the differences in dredging quantities between 12.19-m (40-ft) and 13.71-m (45-ft) projects in shoaling prediction. However, Nancy Young of the Galveston District informed in her e-mail dated August 7, 2000 that "The channel was deepened sometime around 1985. There are some problems with interpolating the dredging history, and there may be no beneficial data obtained for the change in depth from 12.2 m (40 ft) to 13.7 m (45 ft.). We'll know something later this month (hopefully)." Due to severe difficulties in obtaining data for the past years, the required data could not be obtained on time for this study. Hence, the shoaling prediction has been based on other available data.

The dredging history data provided by the District did not provide a breakup of quantities into capital dredging and maintenance dredging. Hence, all quantities were considered as maintenance dredging. Therefore the future dredging estimates given in the report are expected to be somewhat on the higher side.

The currents in Corpus Christi Bay are predominantly wind-driven. Hence, the sediment transport in the area depend more on the wind conditions than on the tidal conditions. It is not possible to estimate future wind climate in the area, which is one of the limitations of the study. The actual dredging quantity each year will vary depending on the wind climate, however it is assumed that the wind climate will remain statistically similar to the present climate over a stretch of several years.

It is reported that due to heavy hurricane activity during 1982, the dredging quantity in the navigation channel shot up to 7.05 million cu m (9.23 million cu yd) compared to 2.26 million cu m (2.96 million cu yd) during 1981 and 1.43 million cu m (1.87 million cu yd) during 1983. The effect of such episodic extreme events has not been considered in the present study.

Conclusions

The Galveston District has proposed deepening of the Corpus Christi Navigation Channel from 13.7 m (45 ft) to 15.2 m (52 ft) and widening of the bay channel from 122 m (400 ft) to 152.4 m (500 ft.) It is estimated that this would result in increasing the average annual total shoaling from the current 1.68 million cu m (2.2 million cu yd) to about 2.3 million cu m (3 million cu yd).

It is estimated that about 30 percent of sediment deposited over the placement areas on the north and south sides of the navigation channel in the Corpus Christi Bay enters back into the navigation channel.

Bibliography

Behrens, E. W., Watson, R. L., and Mason, C. (1977). "Hydraulics and dynamics of new Corpus Christi Pass, Texas: A case history, 1972-73," Report prepared for U.S. Army Coastal Engineering Research Center by University of Texas Marine Sciences Institute, Port Aransas, and Texas A&M University, College Station, TX.

Powell G., Matsumoto, J., and Longley, W. L. (1997). "Effects of structures and practices on the circulation and salinity patterns of the Corpus Christi Bay National Estuary Program study area," Texas Water Development Board, Publication CCBNEP-19.

Ray G., and Clarke, D. (1999). "Environmental assessment of open water placement of maintenance dredged material in Corpus Christi Bay, TX," Technical Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Smith, T. M., McAnally, W. H. and Teeter, A. M. (1987). "Corpus Christi Inner Harbor shoaling investigation," Technical Report HL-87-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

U.S. Army Corps of Engineers. (1965). "Sedimentation problems in entrance of turning basin," Committee on Tidal Hydraulics, Corpus Christi, TX.

Watson, R. L., and Behrens, W. William. (1976). "Hydraulics and dynamics of new Corpus Christi Pass, Texas: A case history, 1973-75," Report prepared for U.S. Army Coastal Engineering Research Center by University of Texas Marine Sciences Institute, Port Aransas, and Texas A&M University, College Station, TX.

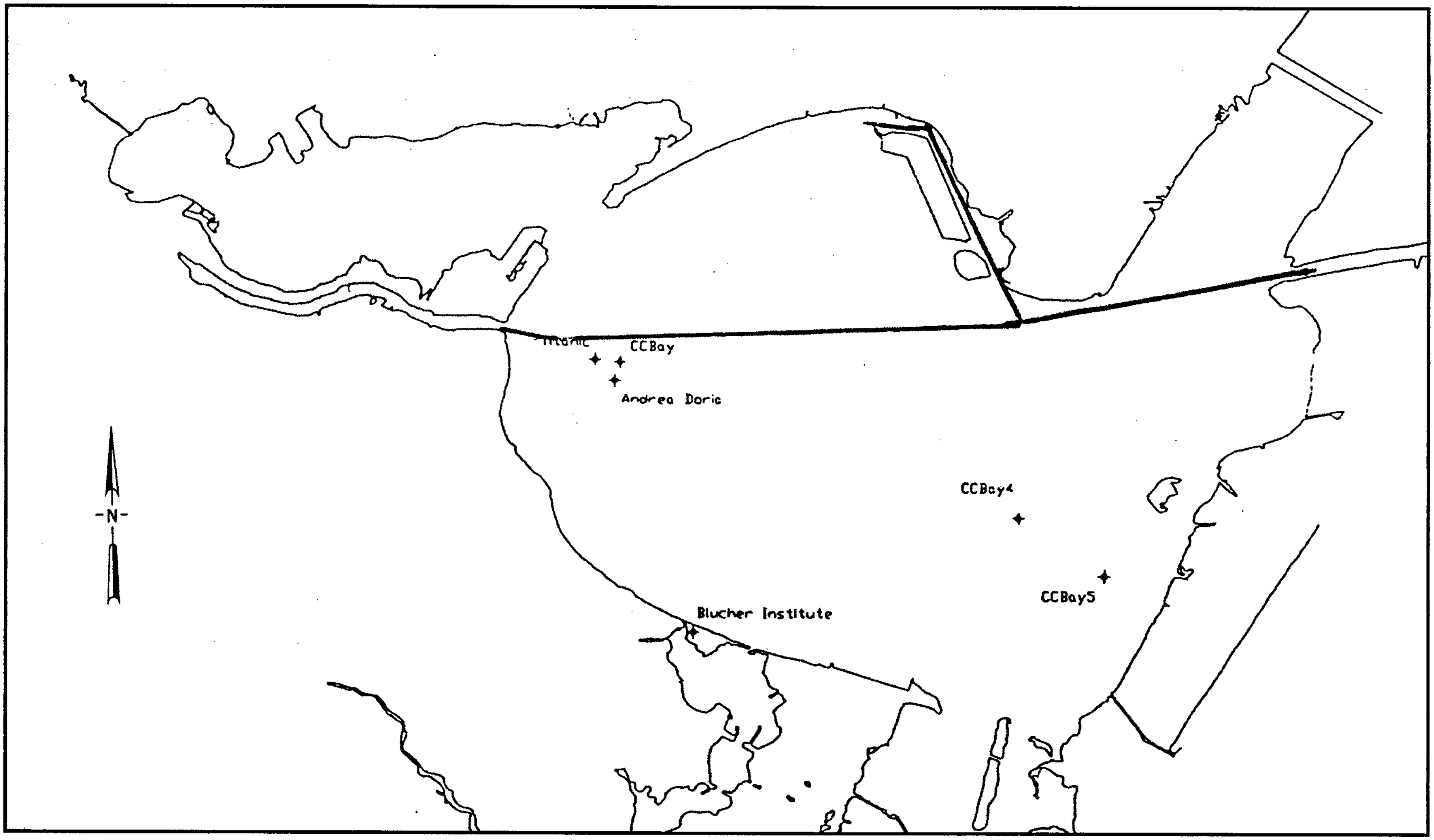


Figure 1. Corpus Christi Bay with locations of data stations (Conrad Blucher Institute 2000)

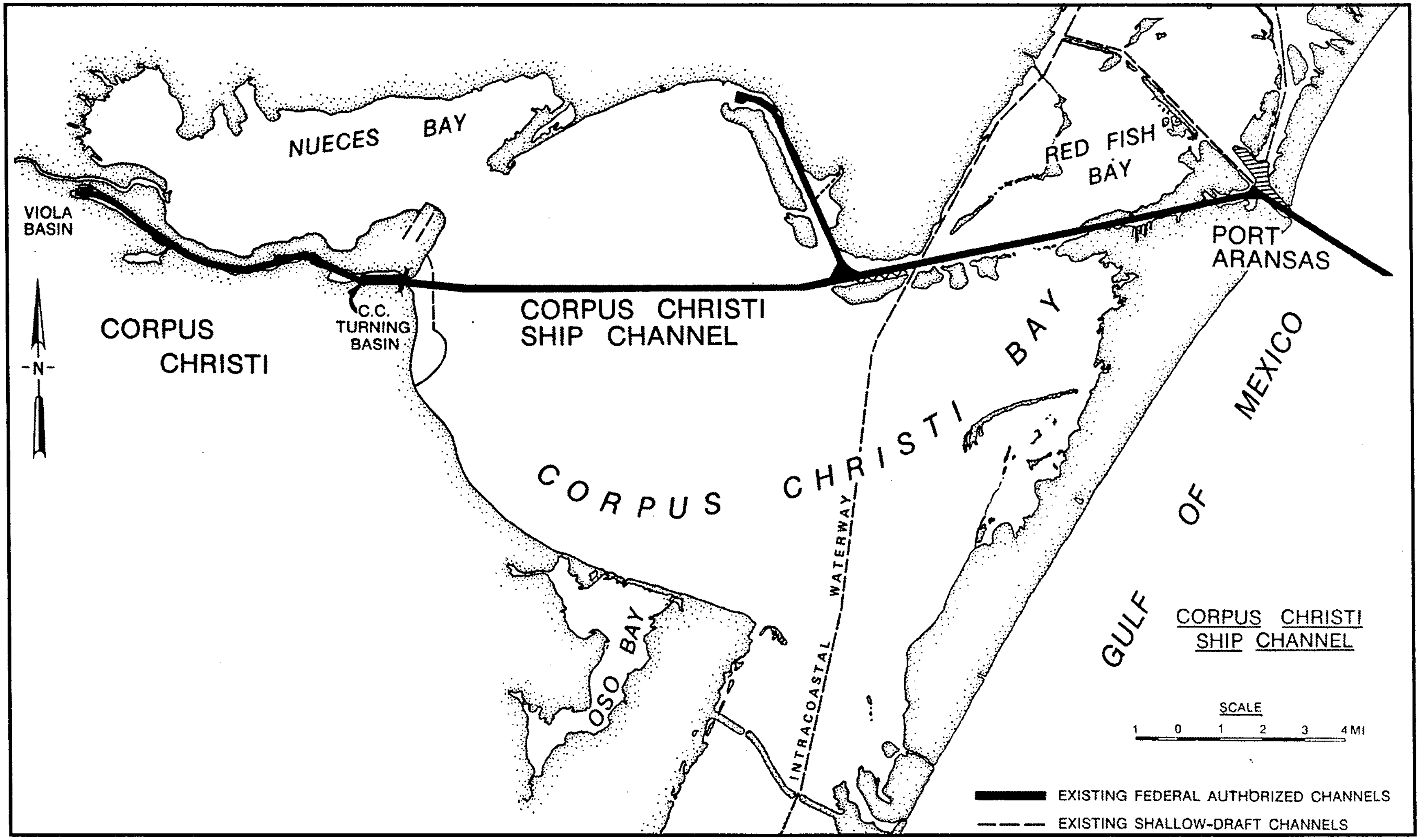


Figure 2. Location map of study area (Watson and Behrens 1976) (To convert miles to kilograms, multiply by 1.609347)

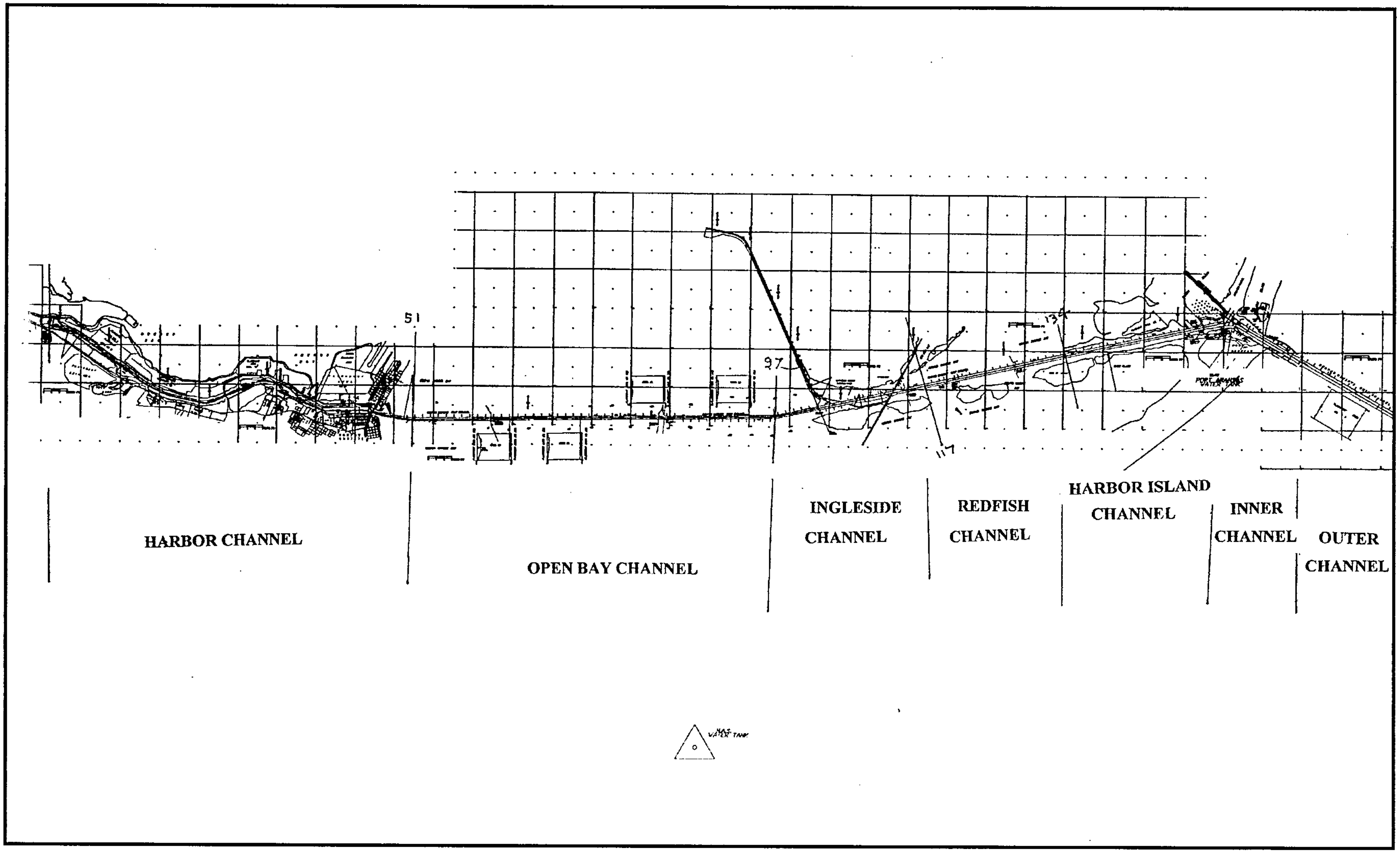


Figure 3. Index map

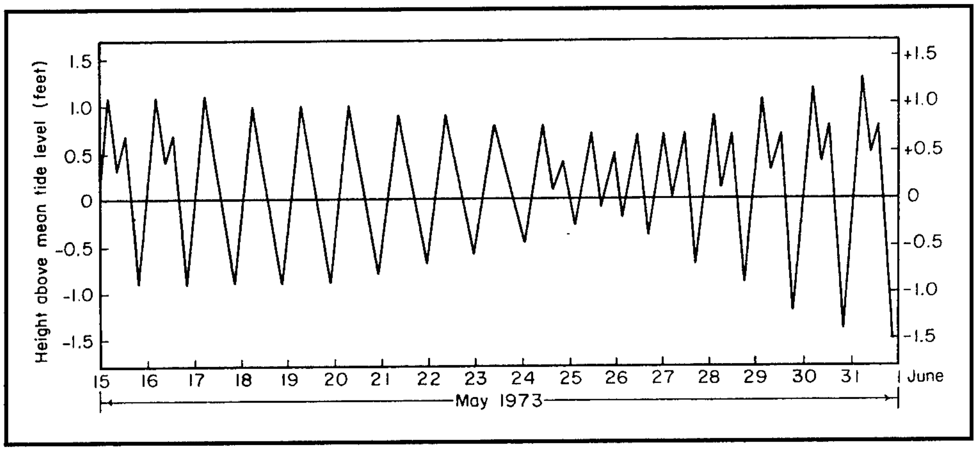
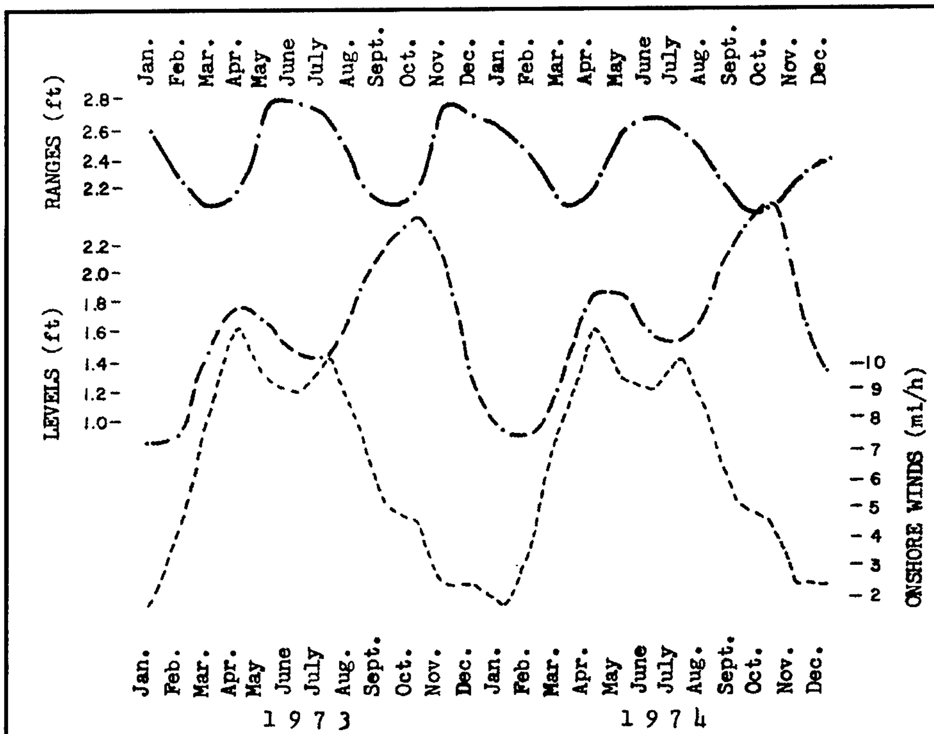


Figure 4. Predicted tides at Aransas Pass, TX for May 1973 (Behrens, Watson, and Mason 1977) (To convert feet to meters, multiply by 0.3048)



Tidal predictions and onshore winds. Ranges are monthly, maximum tidal ranges; levels are averages of monthly highest high, lowest high, highest low, and lowest low; and winds are the average, monthly, resultant windspeeds times the sine of the angle between the shoreline and the resultant direction (data from National Oceanic and Atmospheric Administration, 1972-75).

Figure 5. Correlation of onshore wind and tidal water levels at Corpus Christi (Watson and Behrens 1976) (To convert feet to meters, multiply by 0.3048)

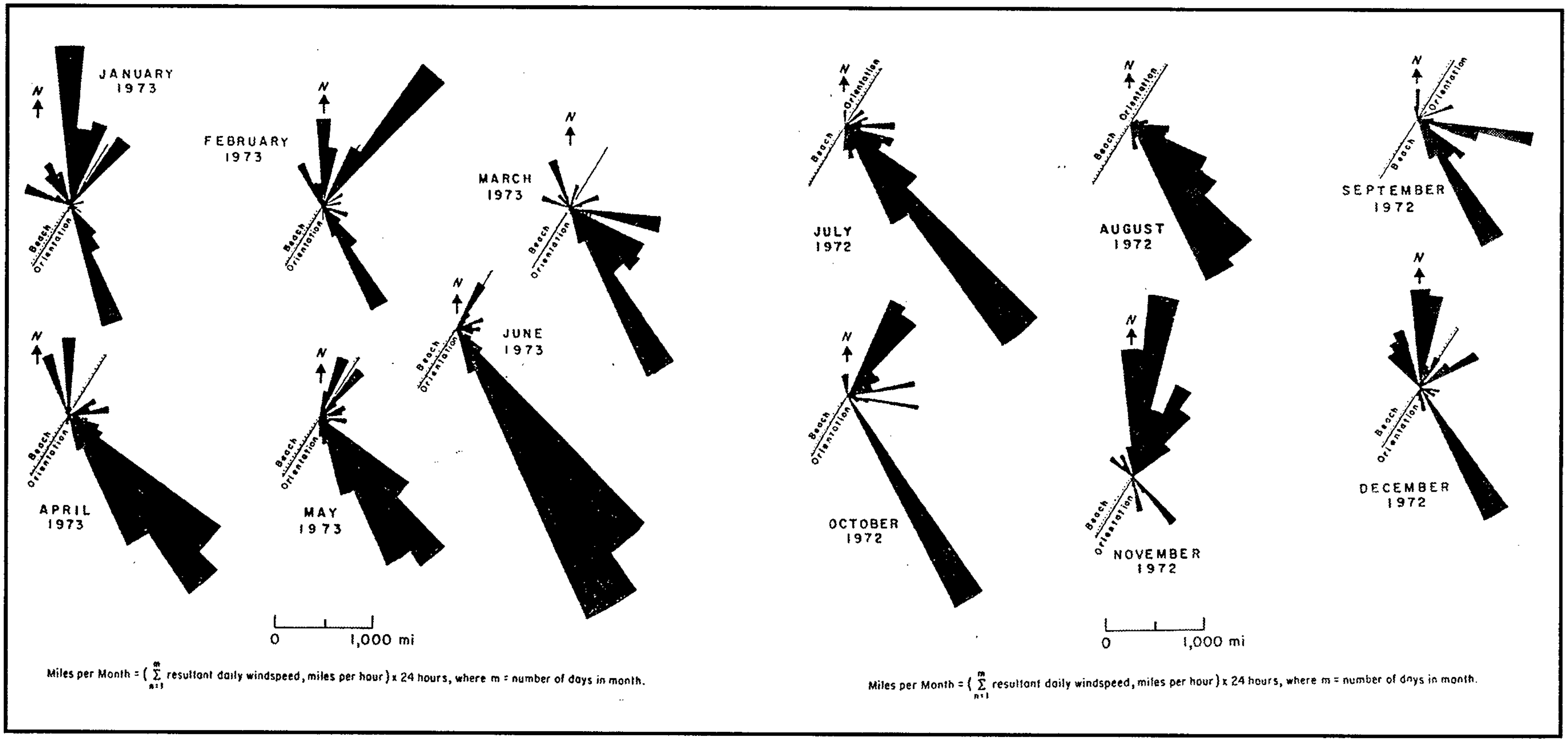


Figure 6. Wind rose diagrams (Watson and Behrens 1976)

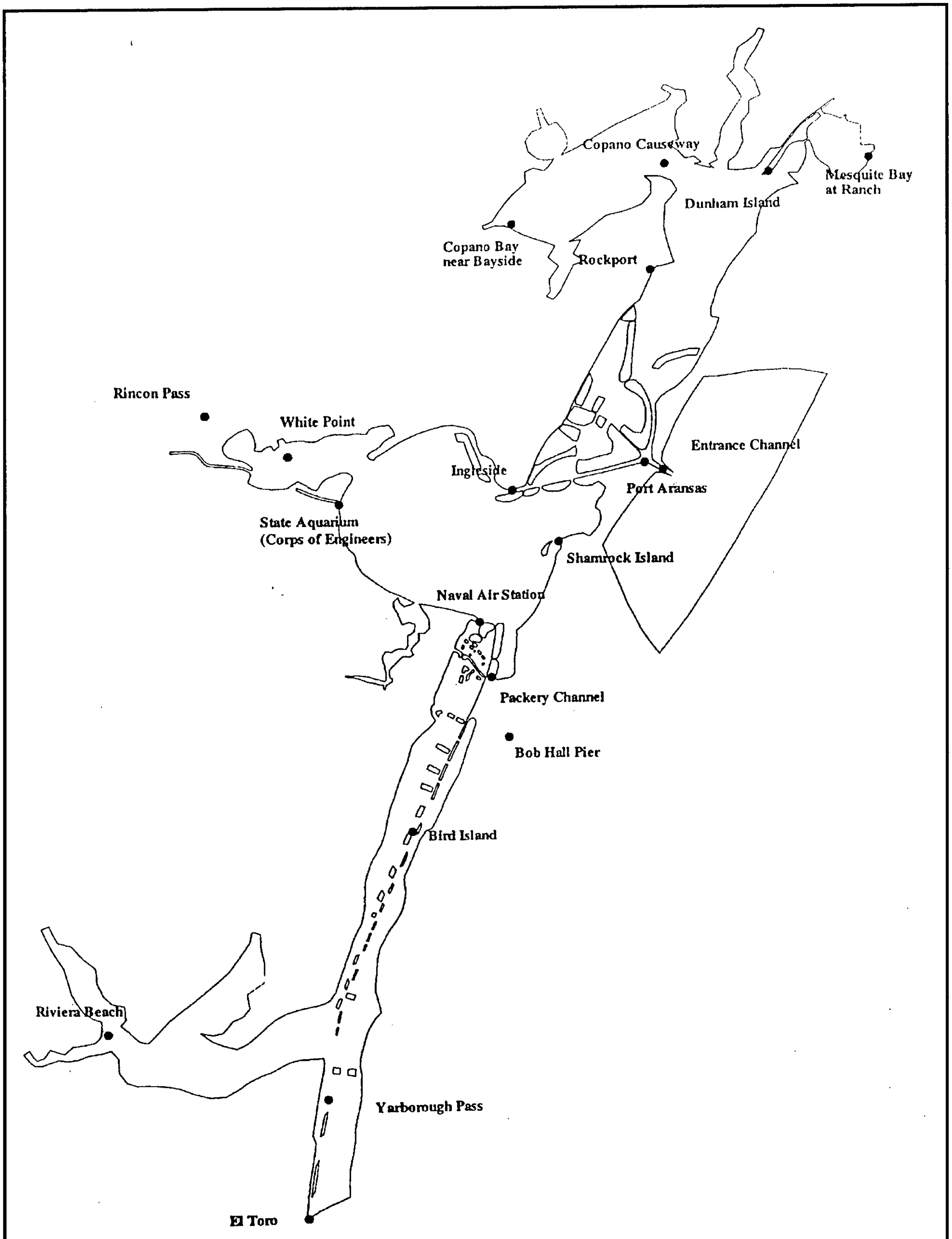


Figure 7. Location of wind and tide observation sta Bob Hall

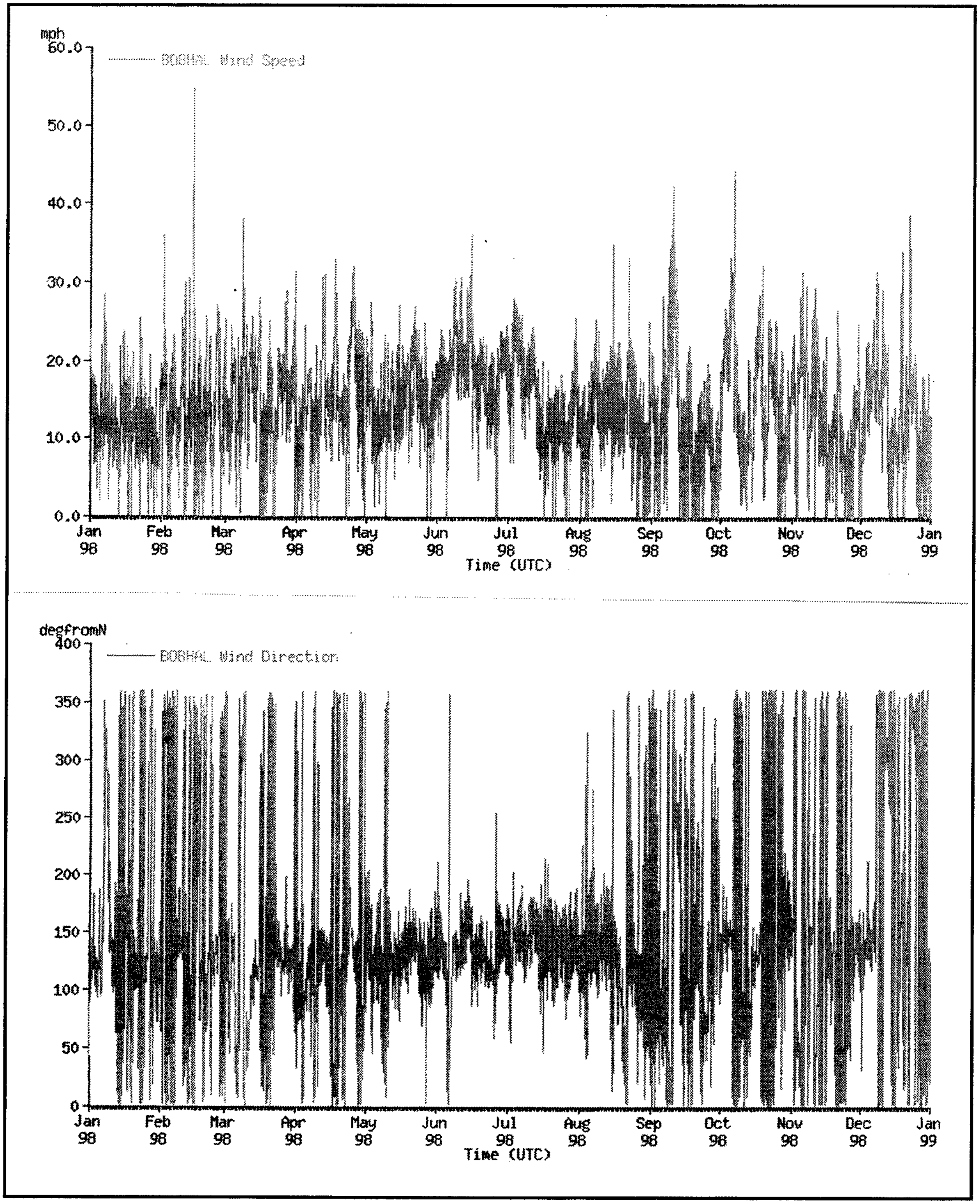


Figure 8. Wind speed and wind direction during January 1998 through January 1999

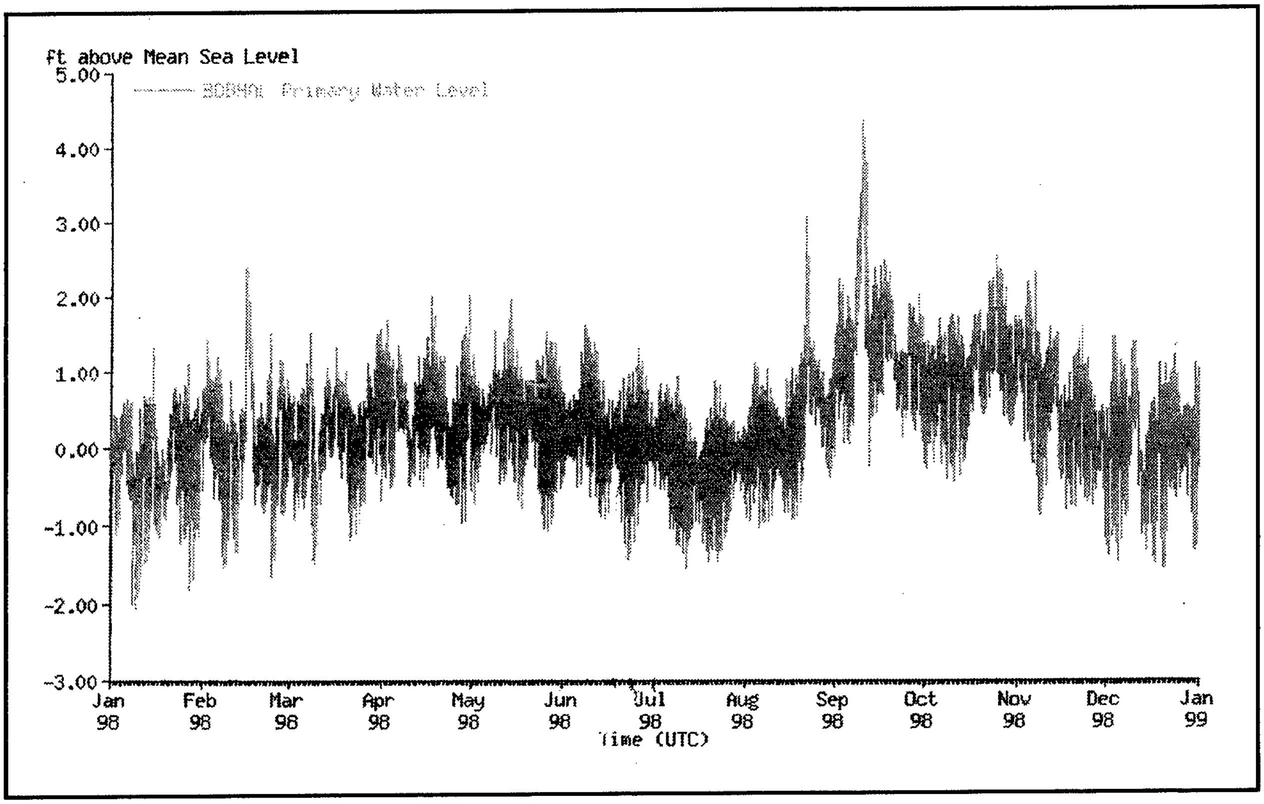


Figure 9. Tidal water level during January 1998 through January 1999 (To convert feet to meters, multiply by 0.3048)

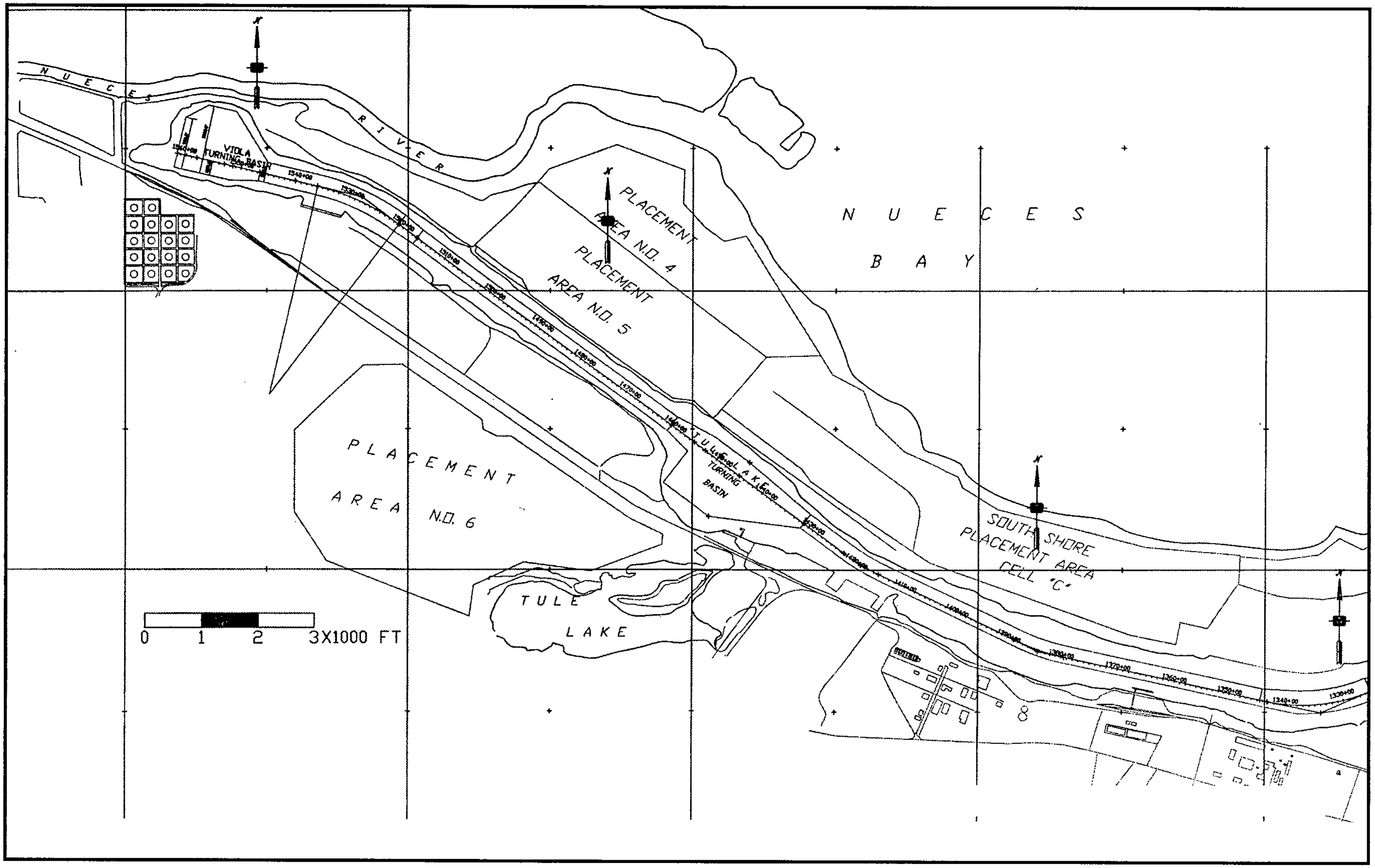


Figure 10. Location of bed samples and water samples (Sheet 1 of 7) (To convert feet to meters, multiply by 0.3048)

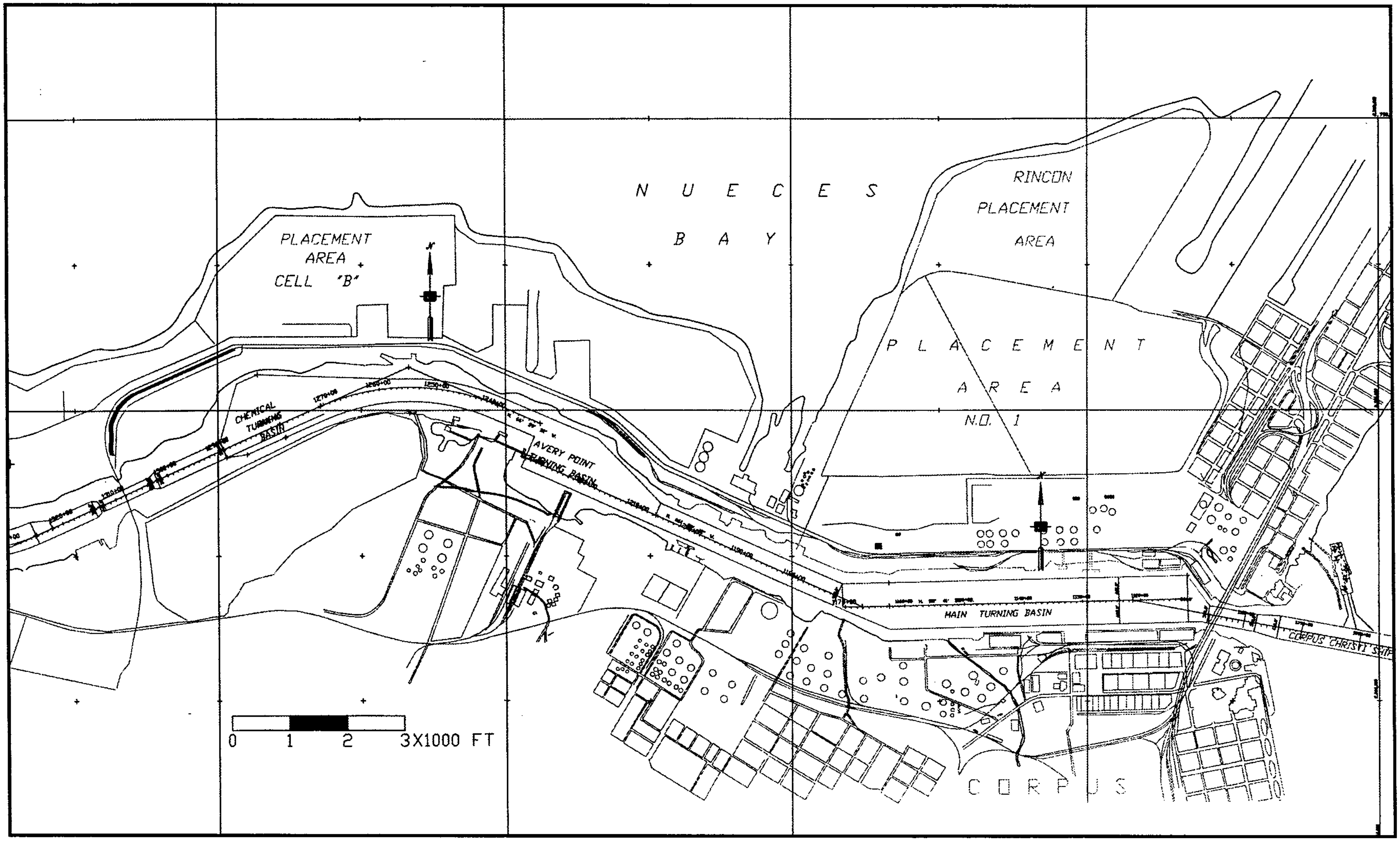


Figure 10. (Sheet 2 of 7)

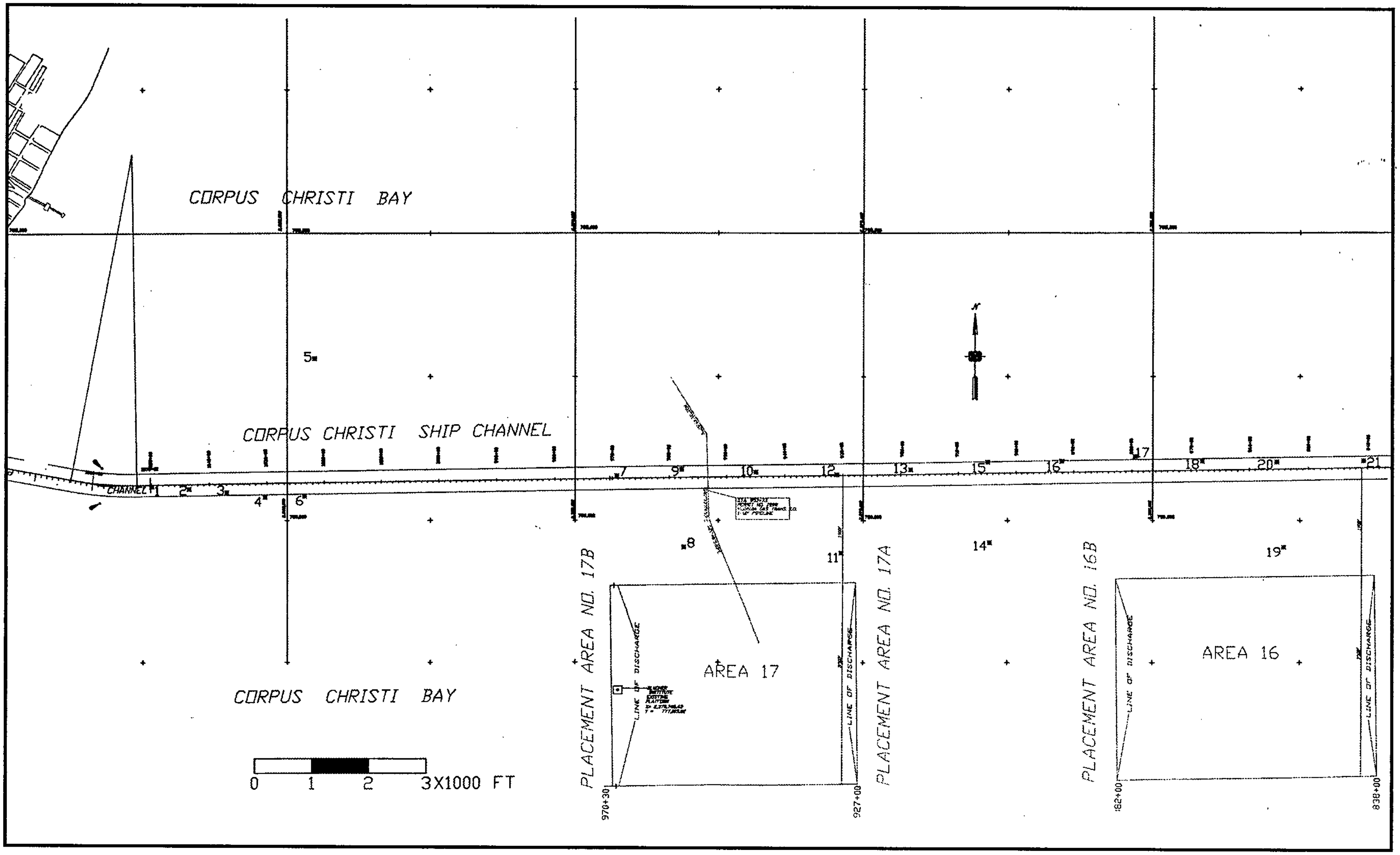


Figure 10. (Sheet 3 of 7)

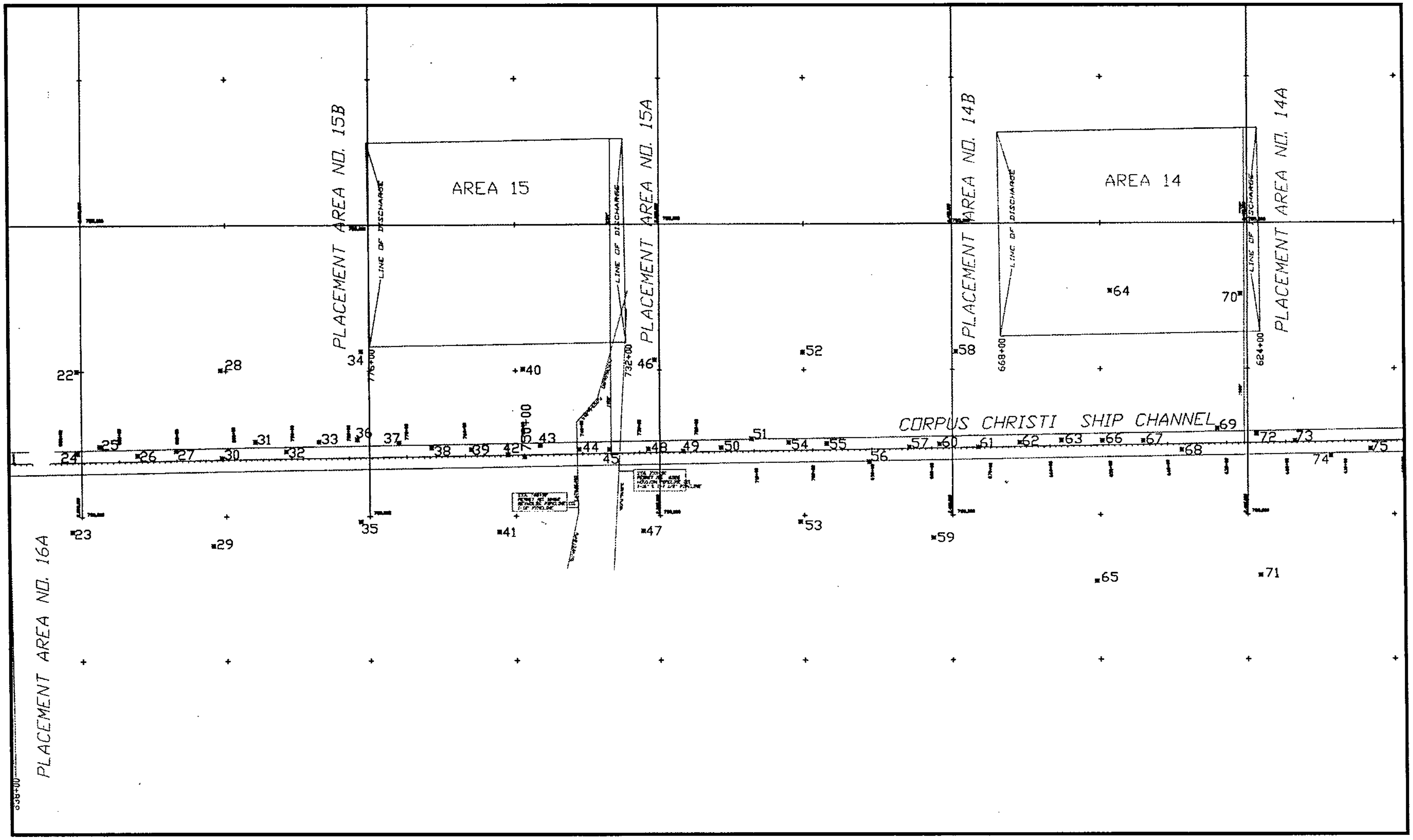


Figure 10. (Sheet 4 of 7)

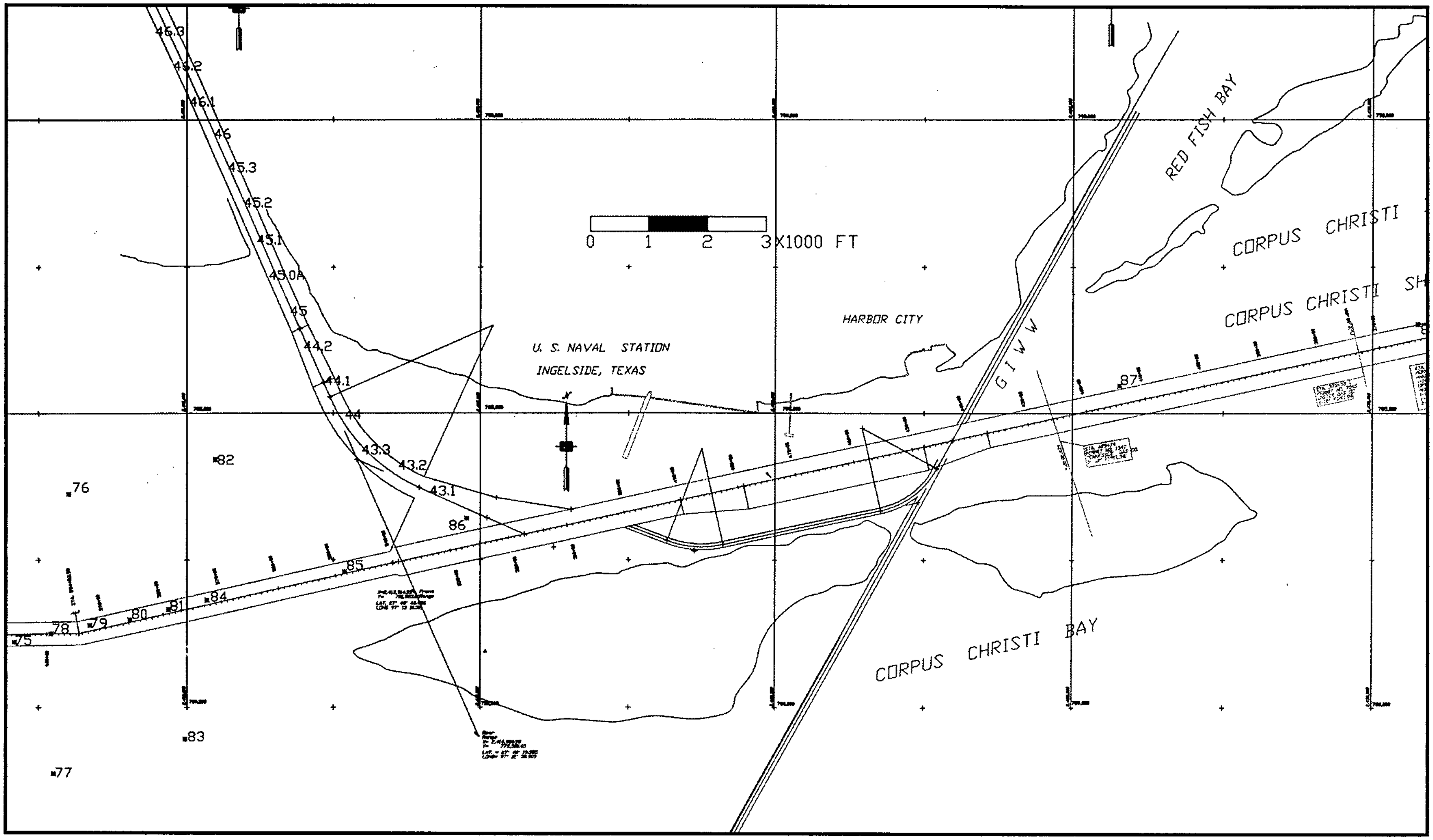


Figure 10. (Sheet 5 of 7)

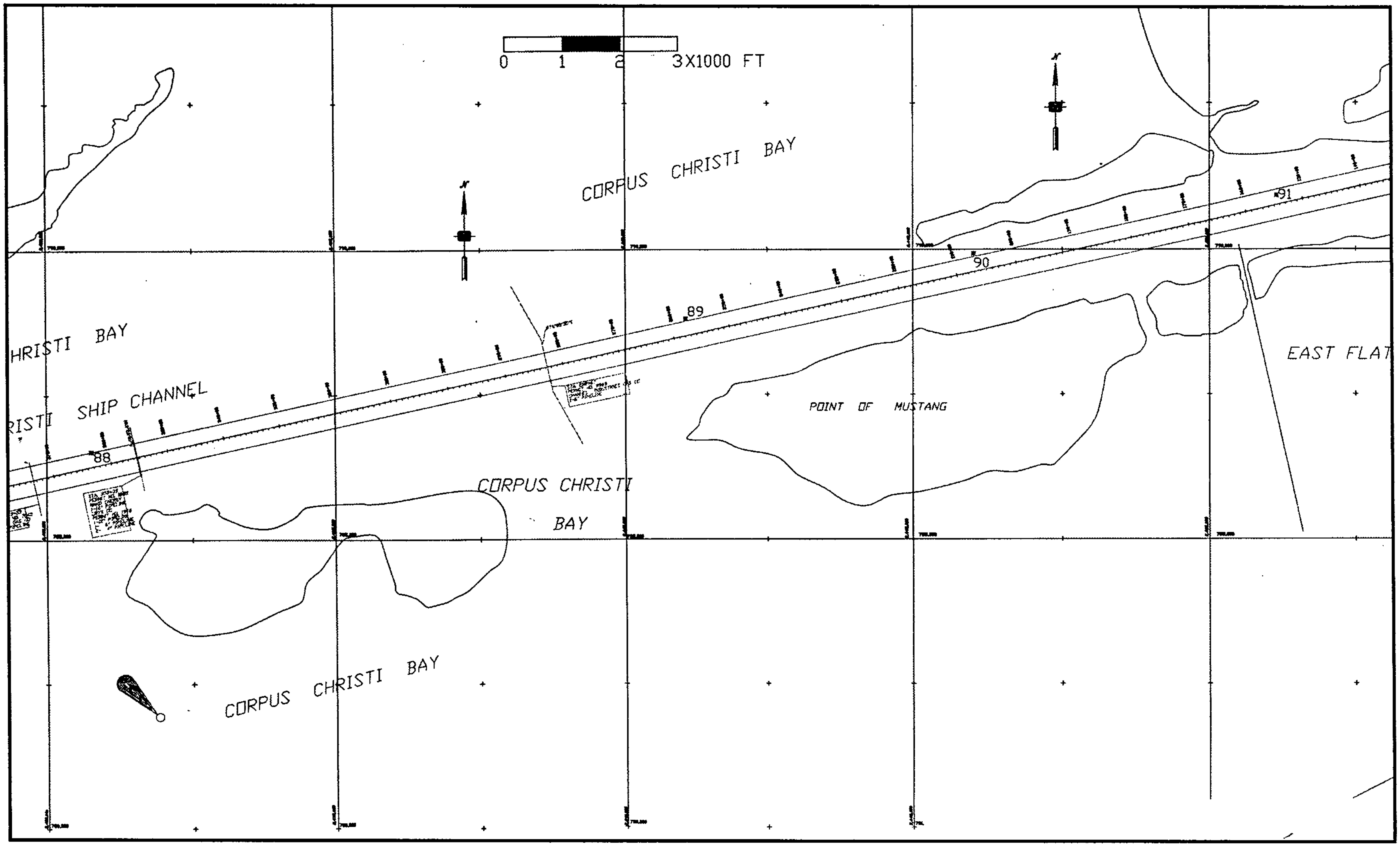


Figure 10. (Sheet 6 of 7)

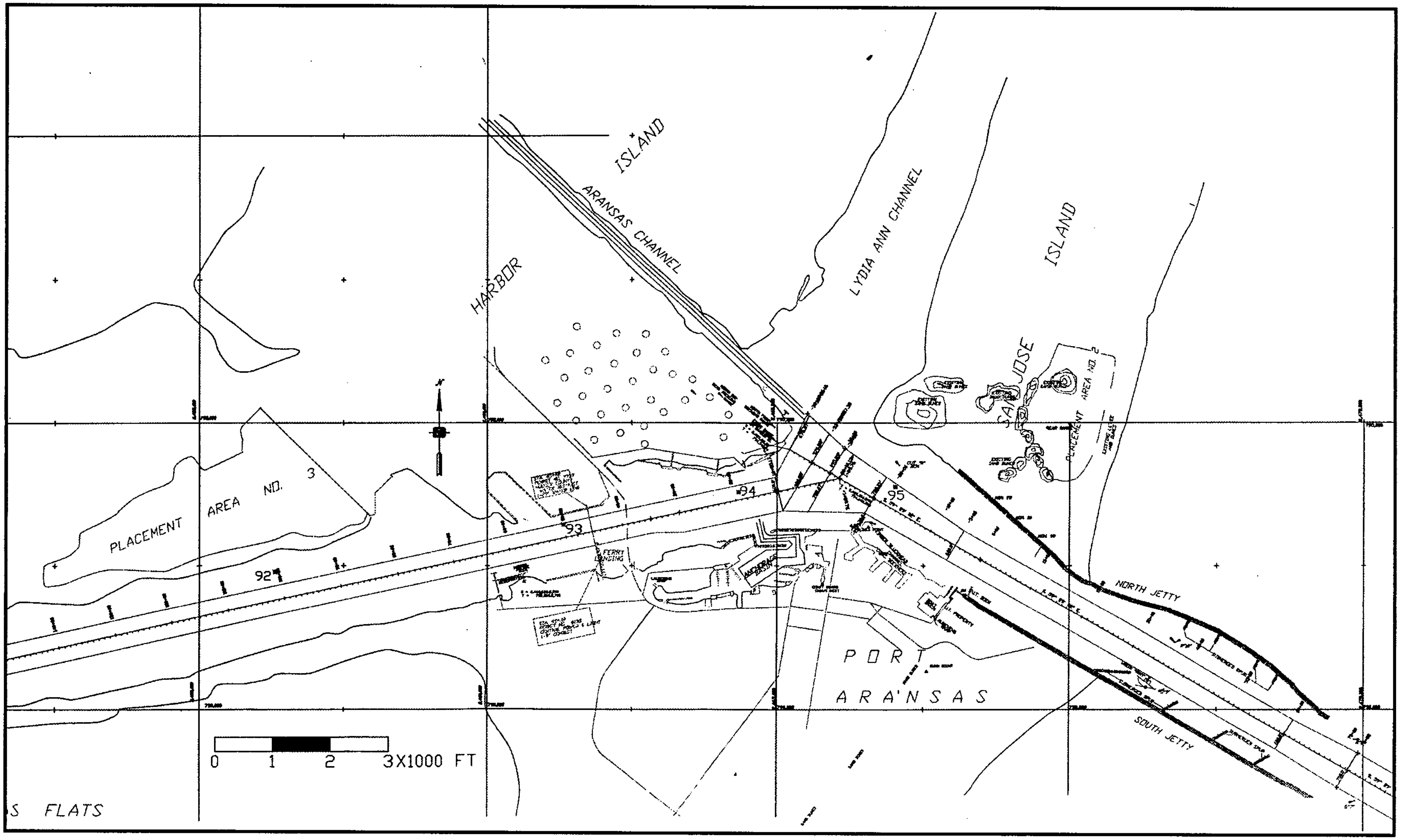


Figure 10. (Sheet 7 of 7)

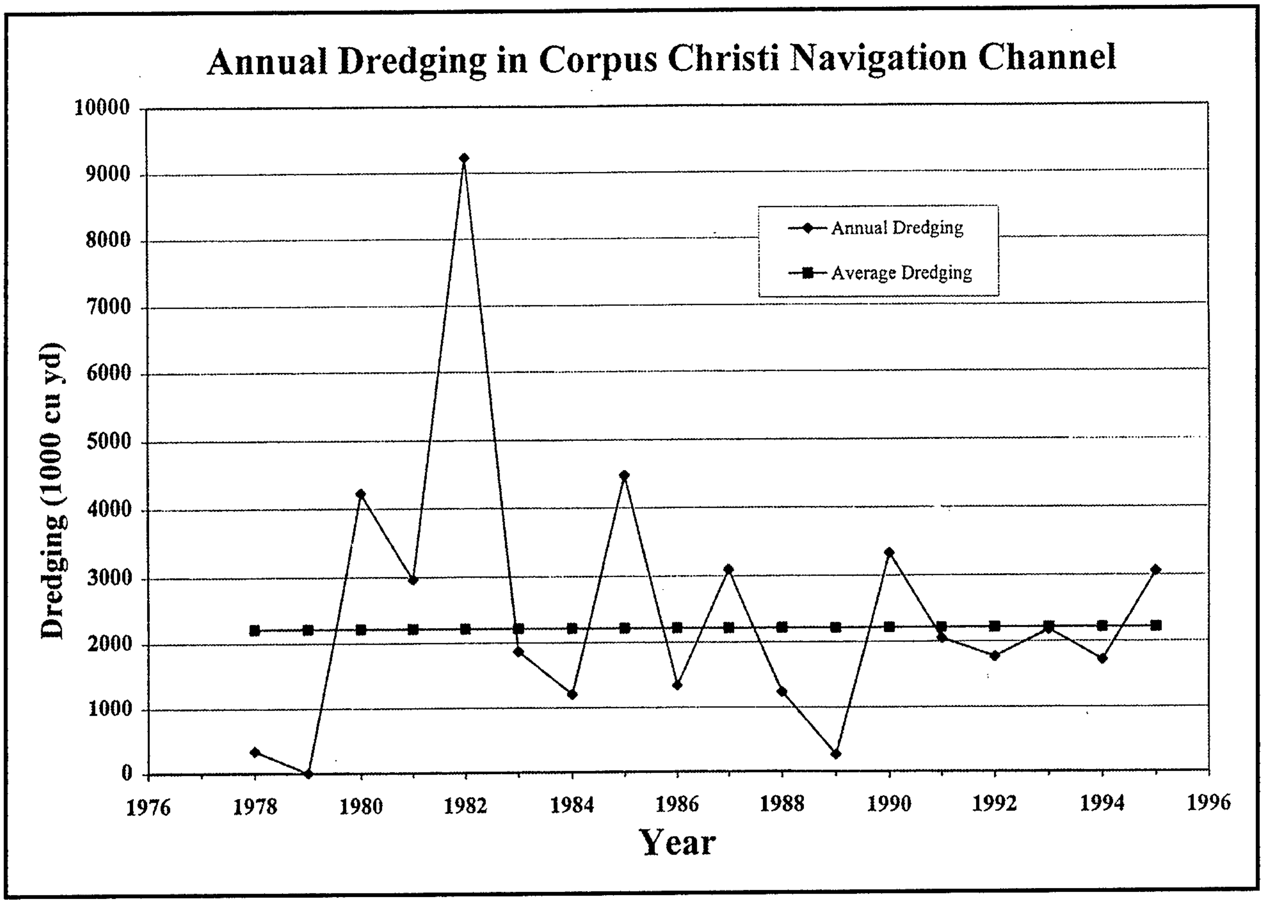


Figure 11. Annual quantities of dredging in Corpus Christi Navigation Channel (To convert cubic yards to cubic meters, multiply by 0.7645549)

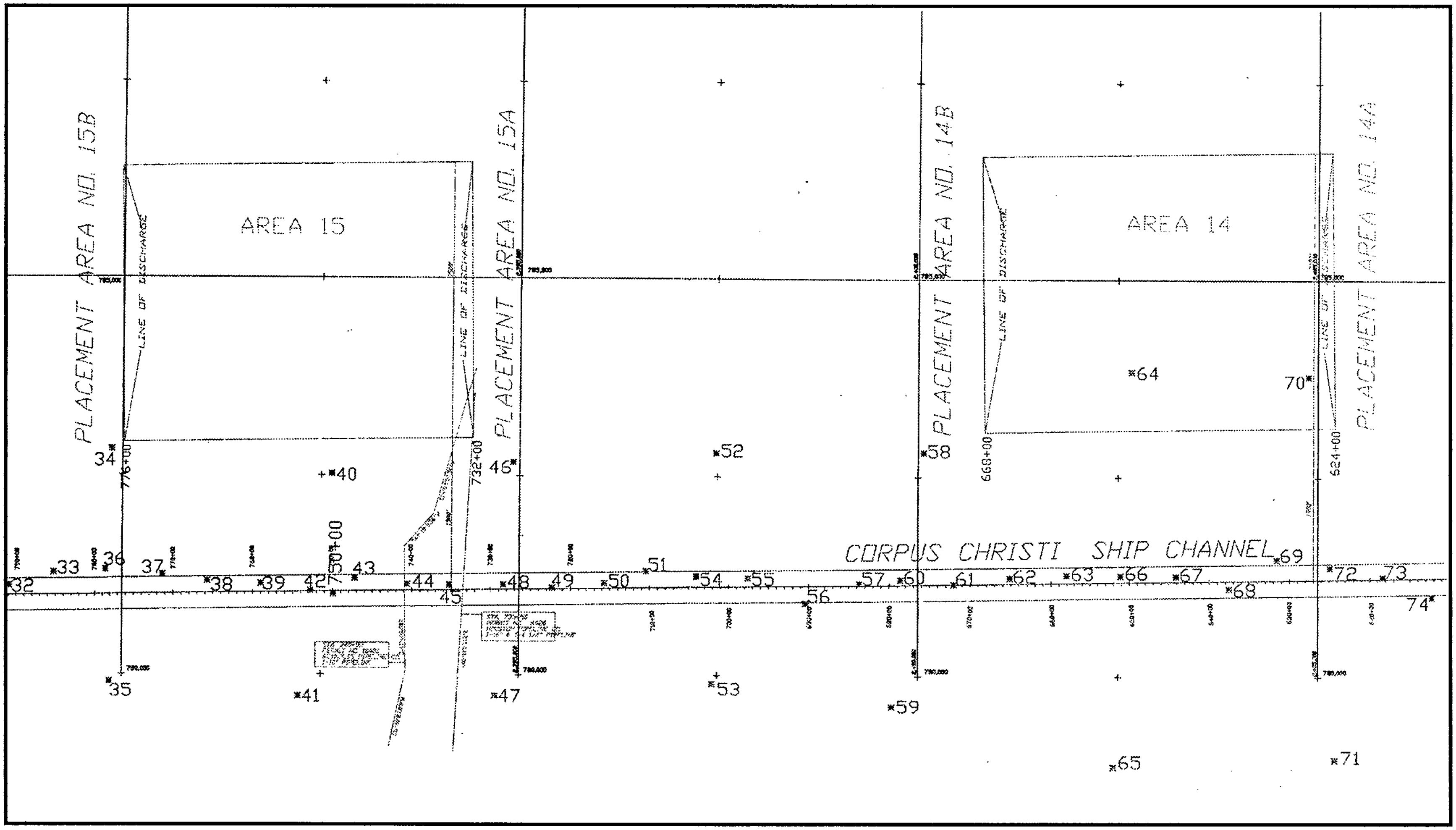


Figure 12. Placement areas 14 and 15

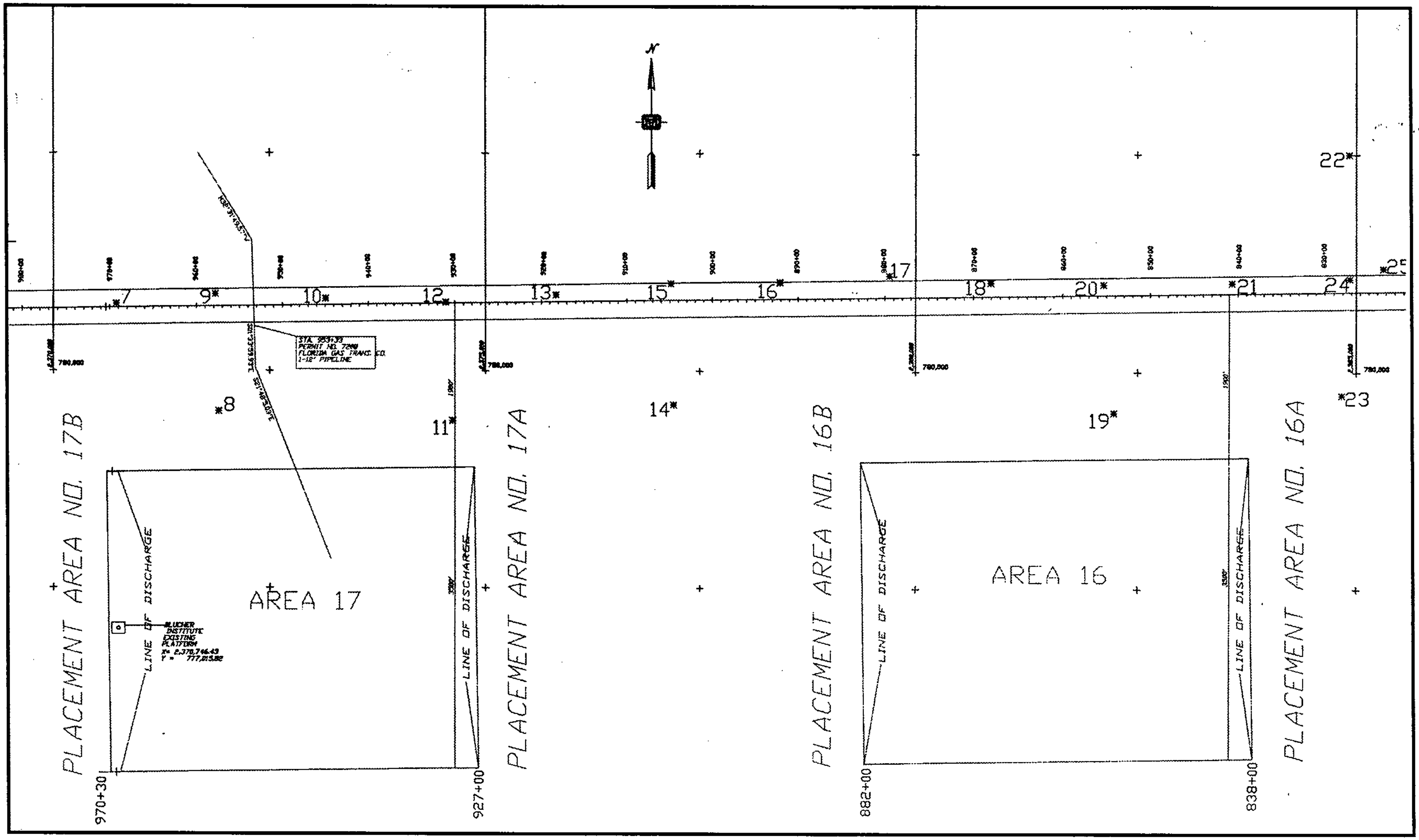


Figure 13. Placement areas 16 and 17

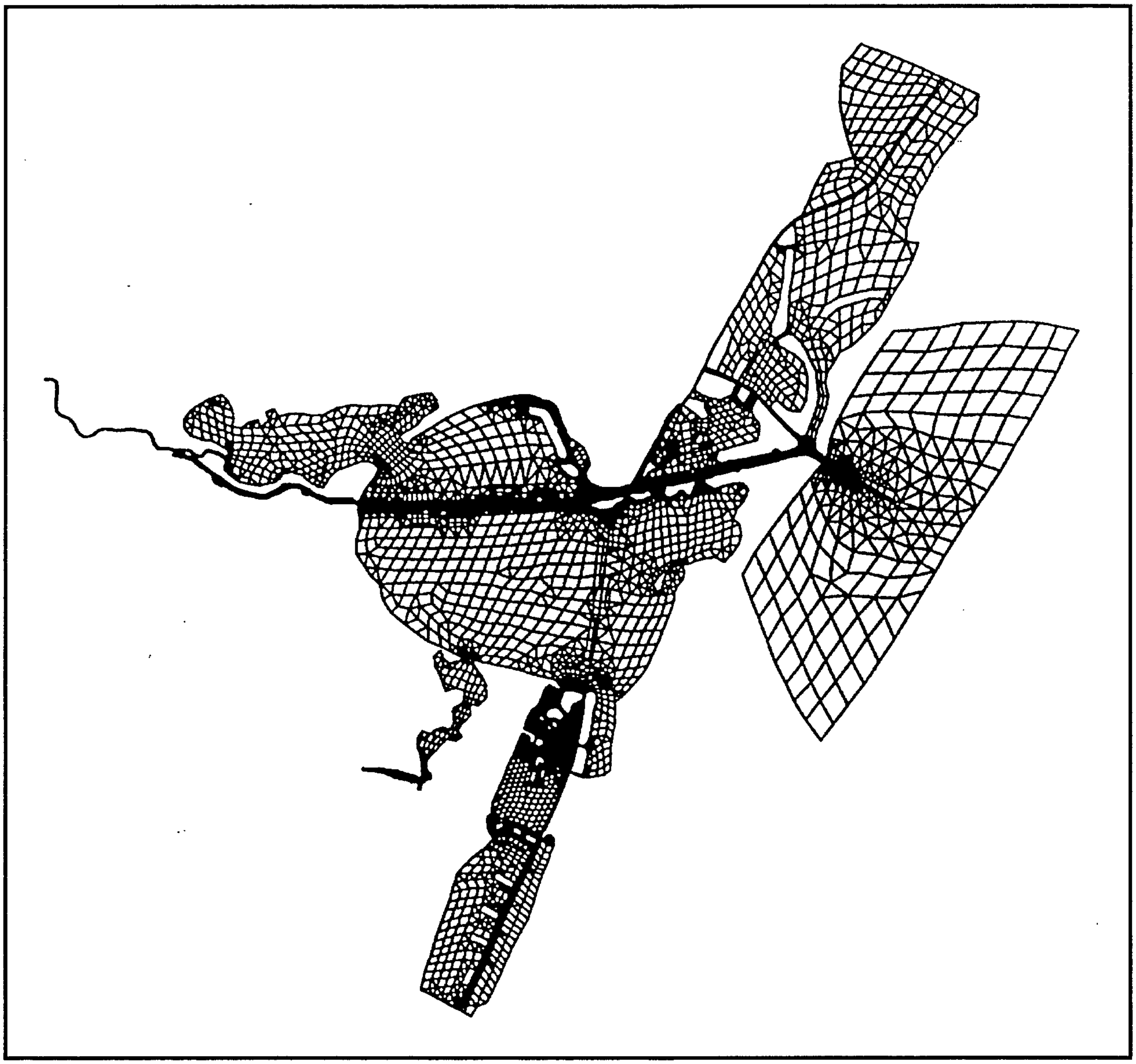


Figure 14. Grid used for numerical model of Corpus Christi Bay and surrounding area

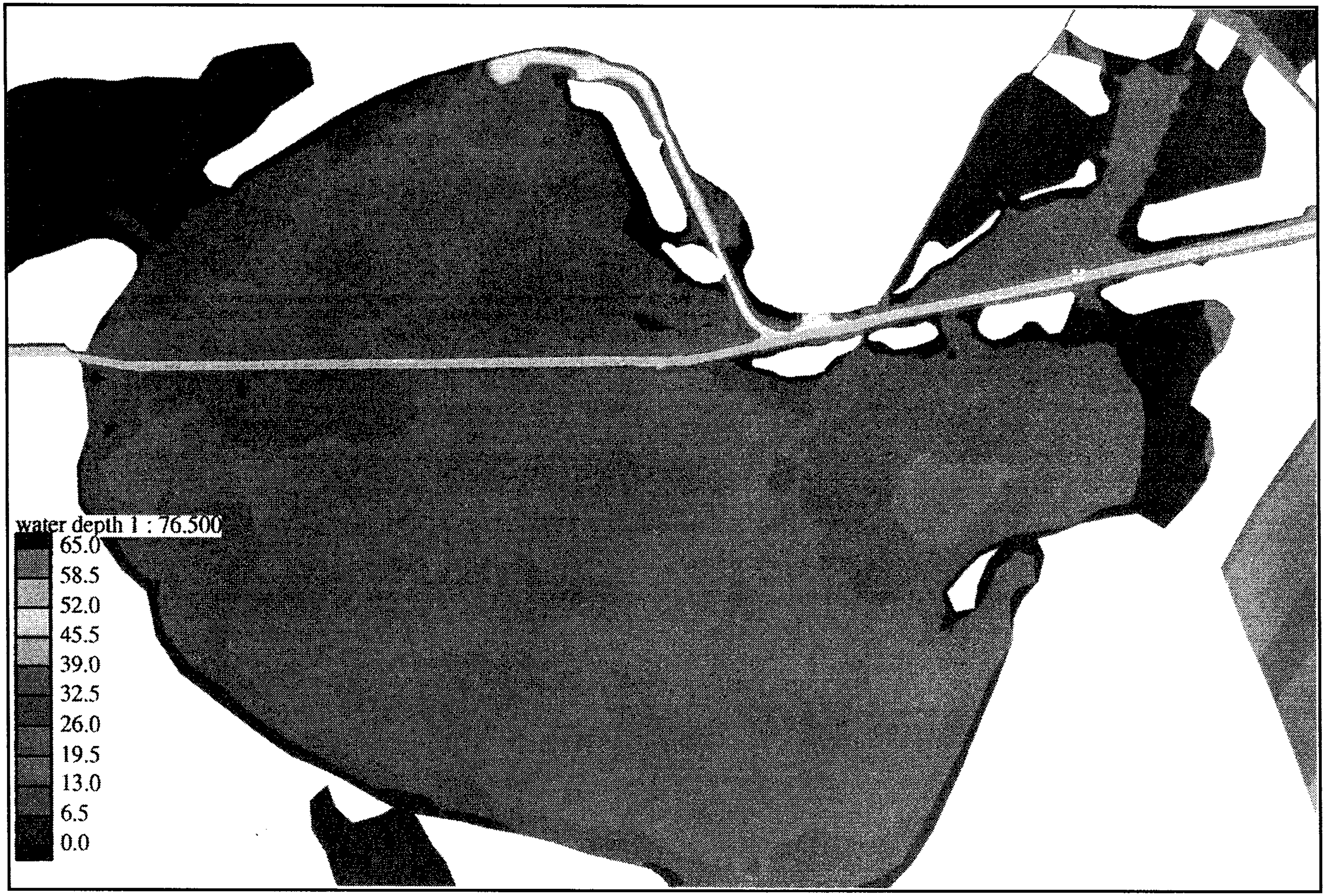
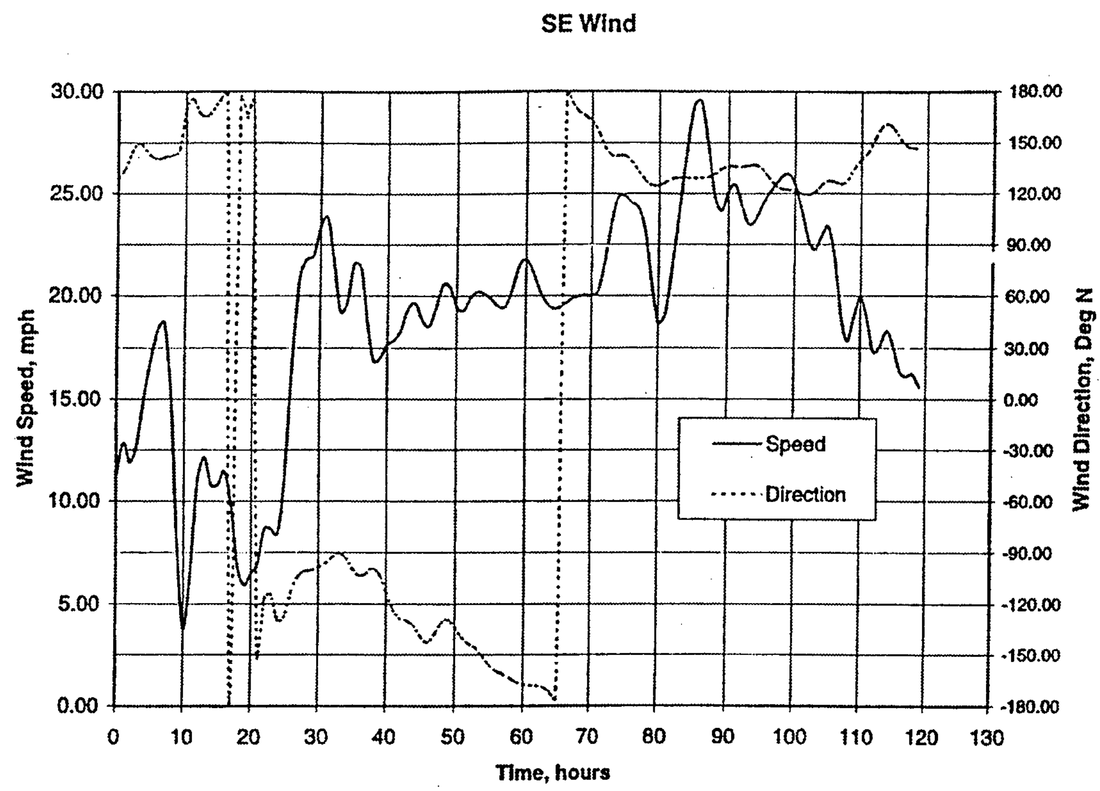


Figure 15. Bathymetry used for numerical model, 1999 data, base condition



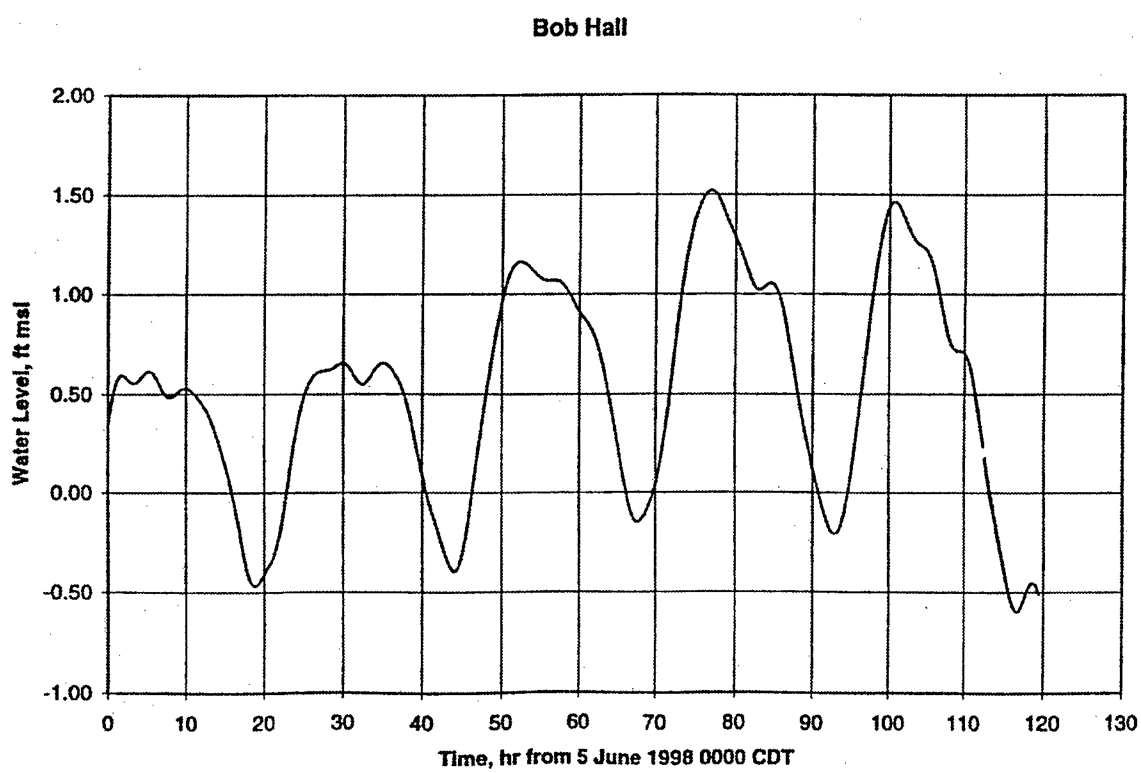


Figure 16. June tides and southeast wind selected for model run (measured at Bob Hall) (To convert feet to meters, multiply by 0.3048)

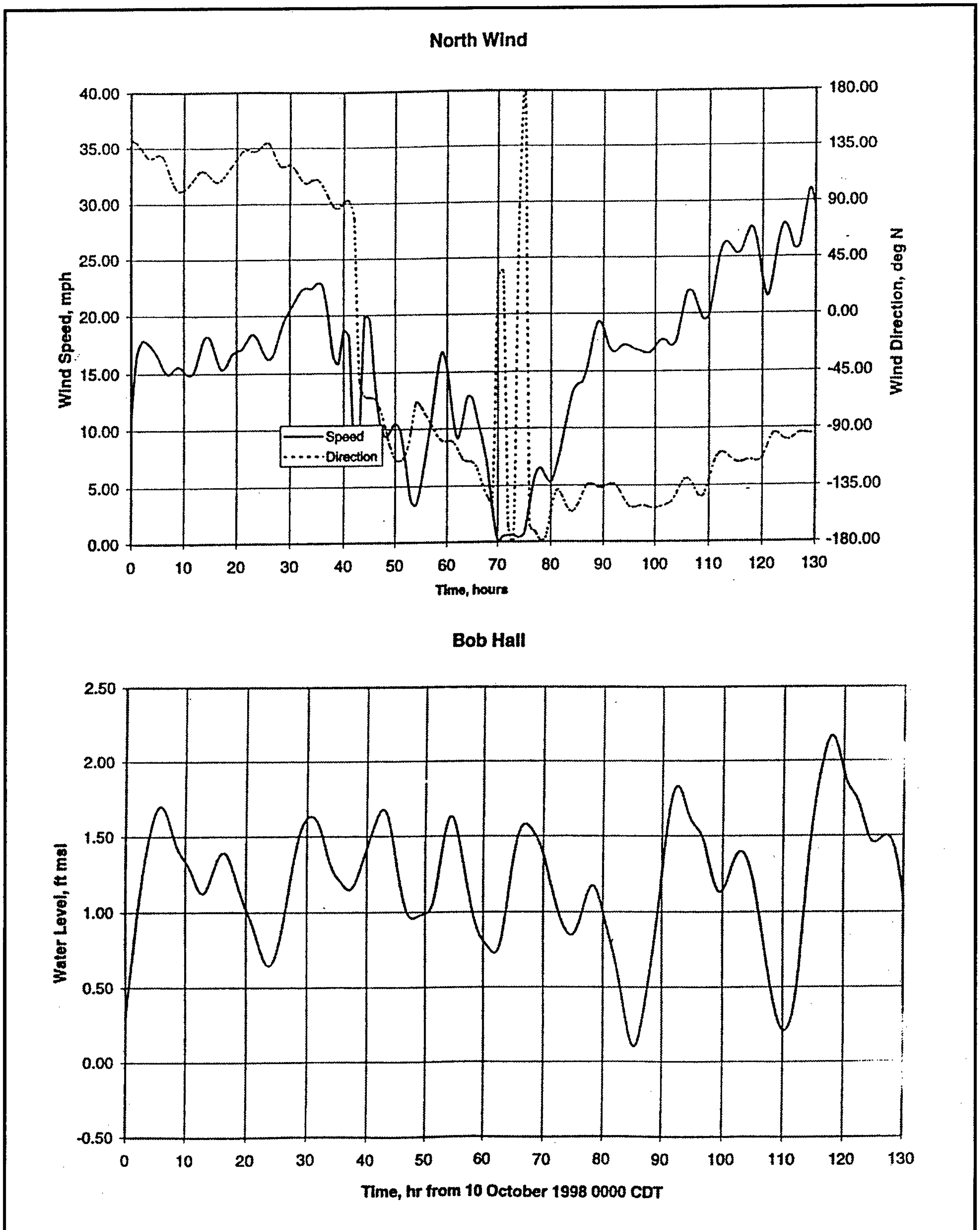


Figure 17. October tides and north wind selected for model run (measured at Bob Hall) (To convert feet to meters, multiply by 0.3048)

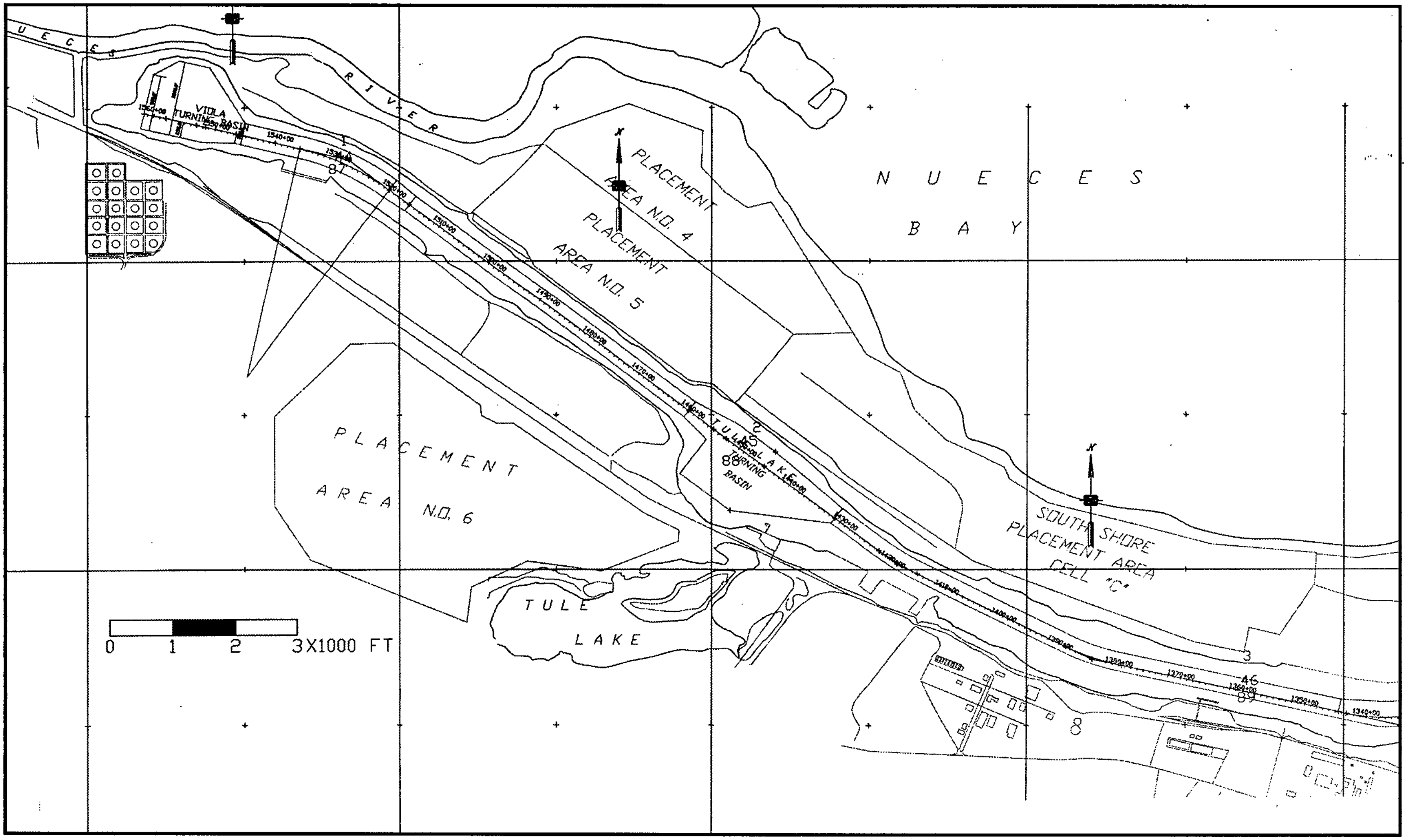


Figure 18. Locations of velocity gages in numerical model (Sheet 1 0f 9) (To convert feet to meters, multiply by 0.3048)

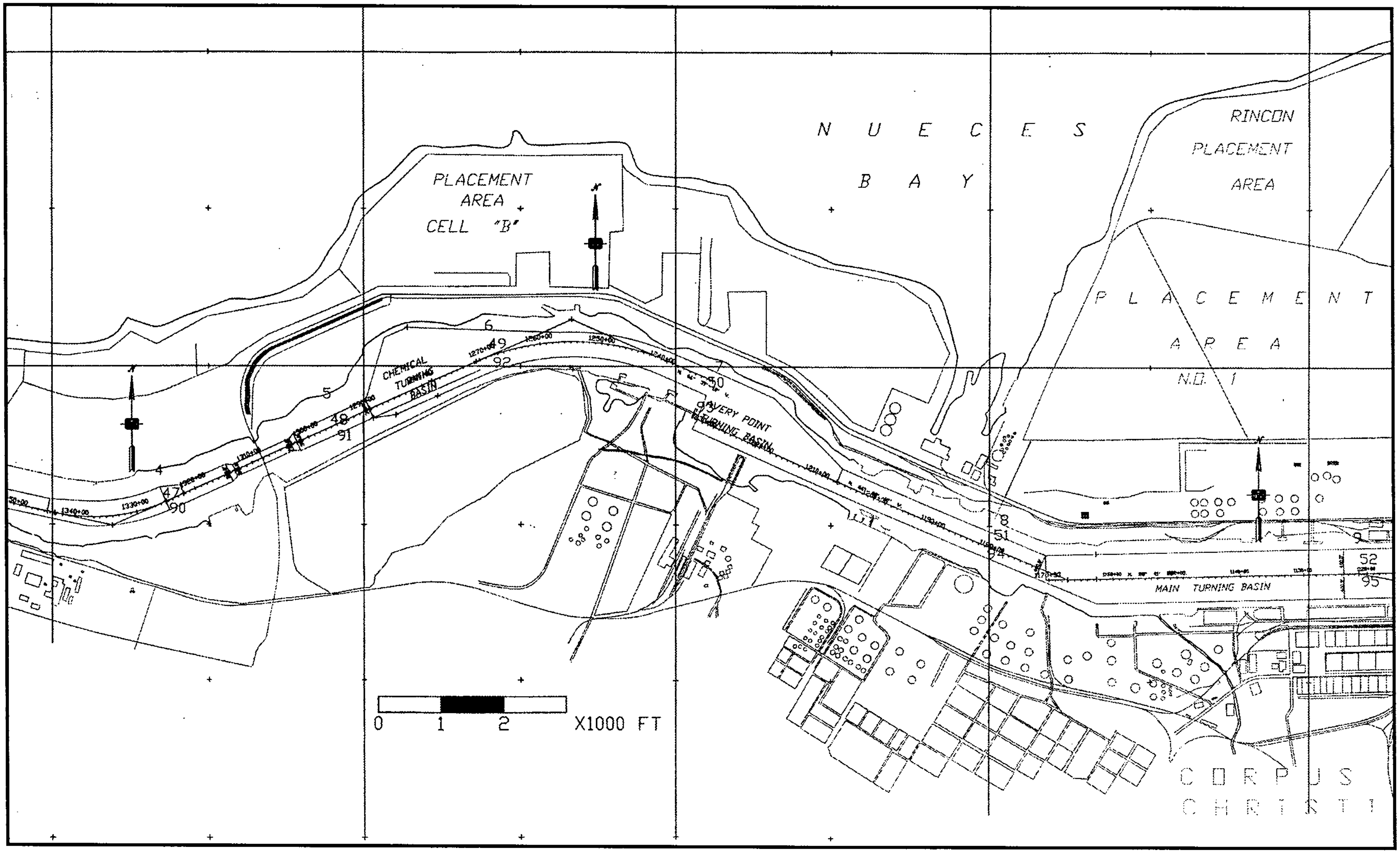


Figure 18. (Sheet 2 of 9)

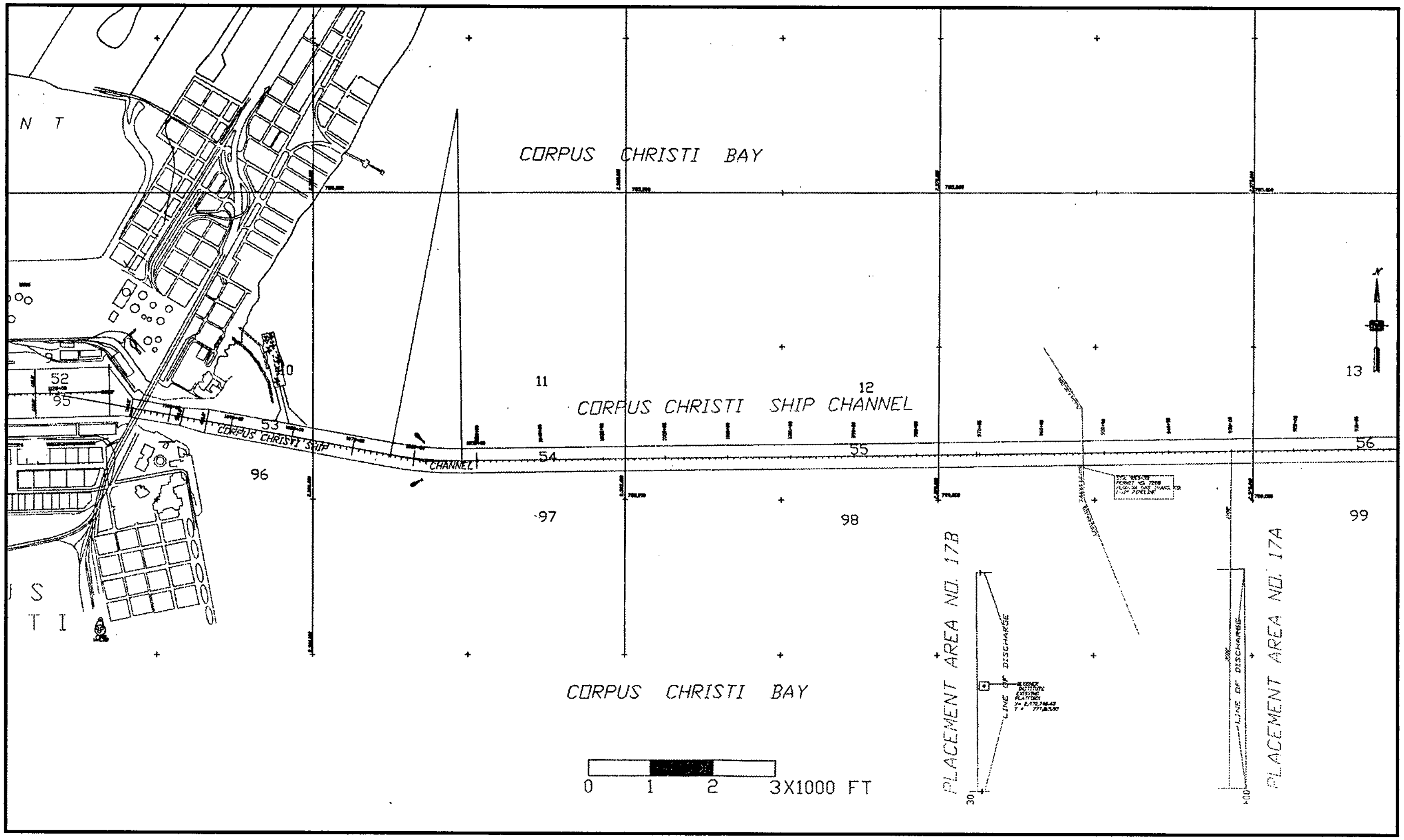


Figure 18. (Sheet 3 of 9)

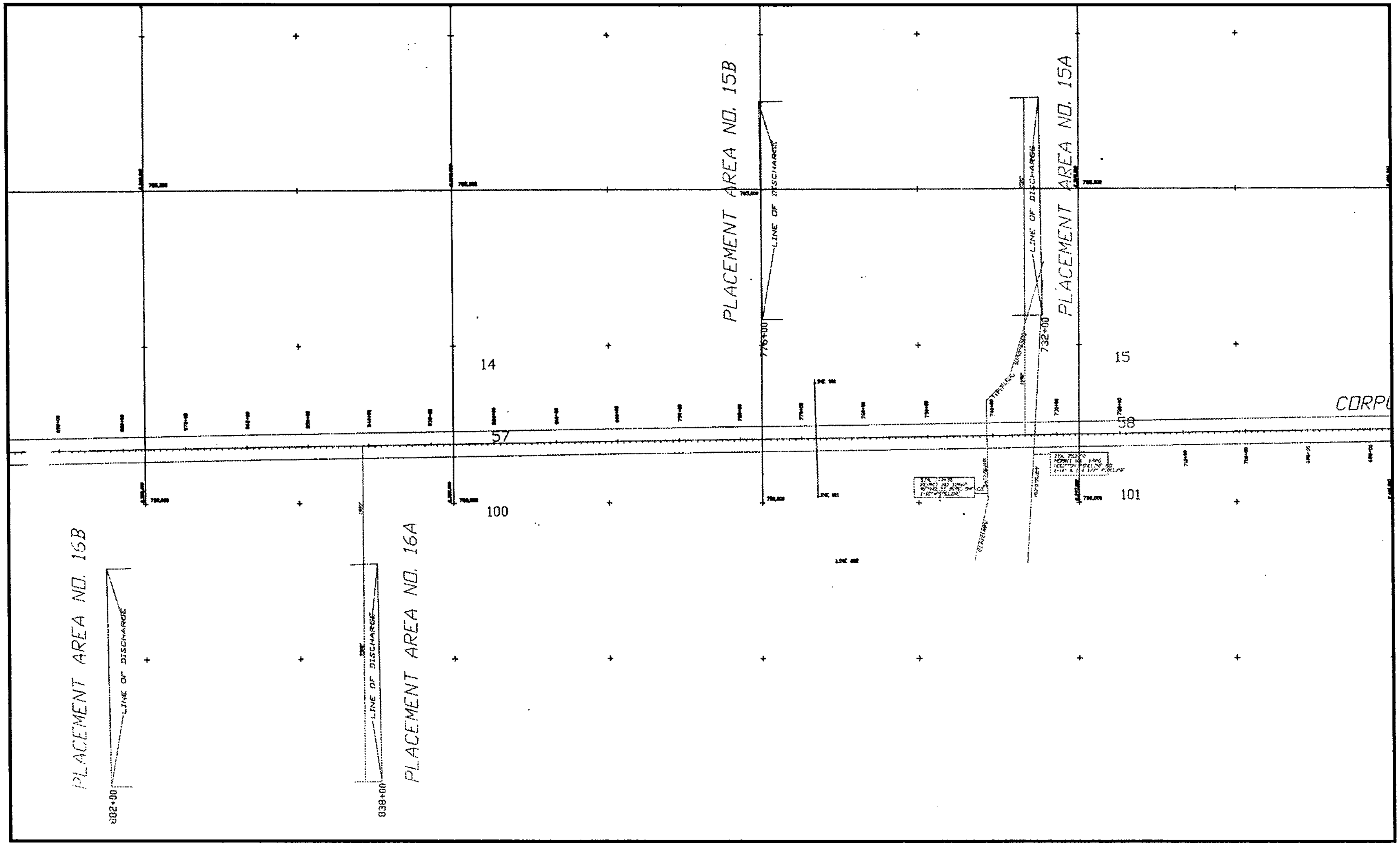


Figure 18. (Sheet 4 of 9)

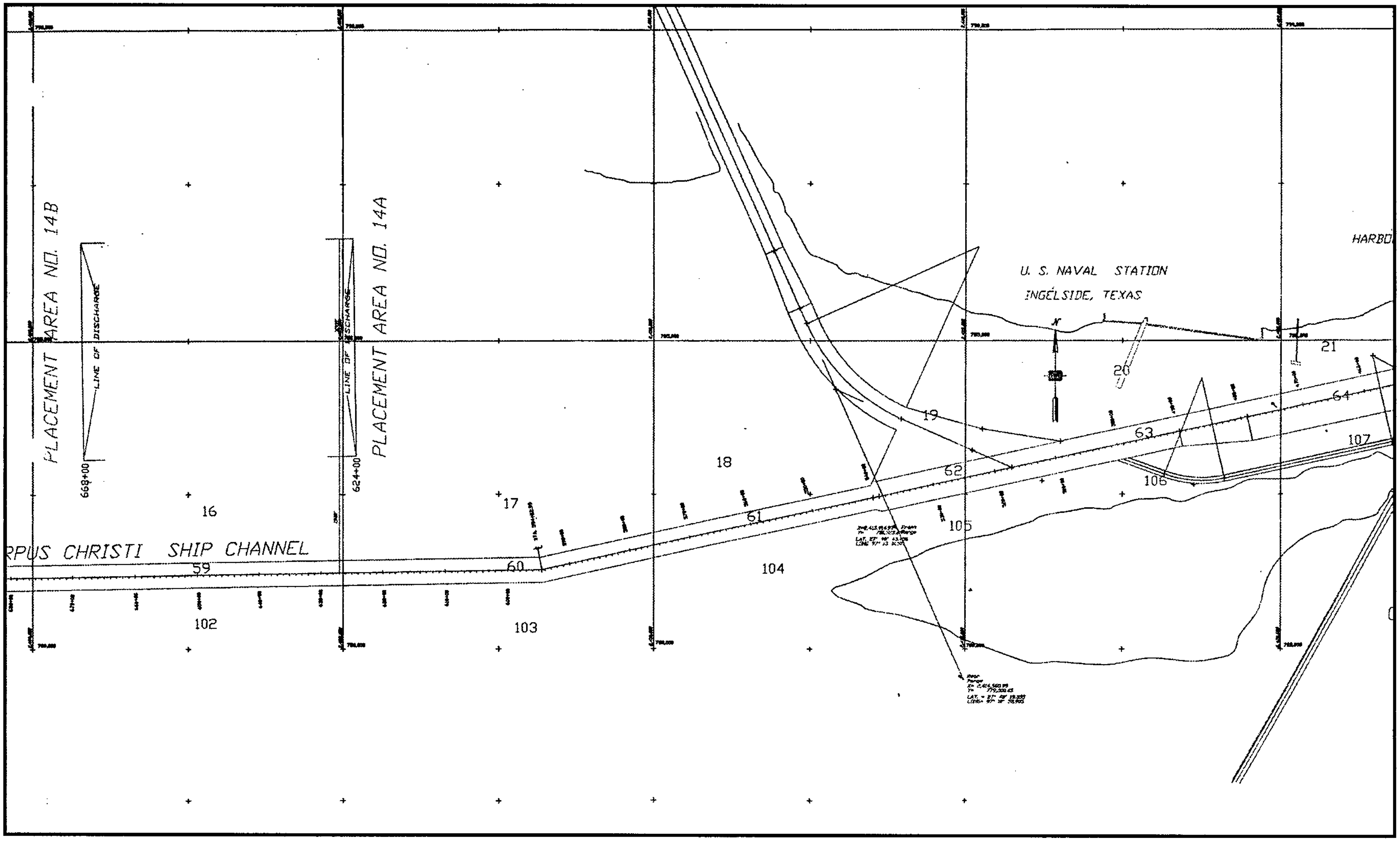


Figure 18. (Sheet 5 of 9)

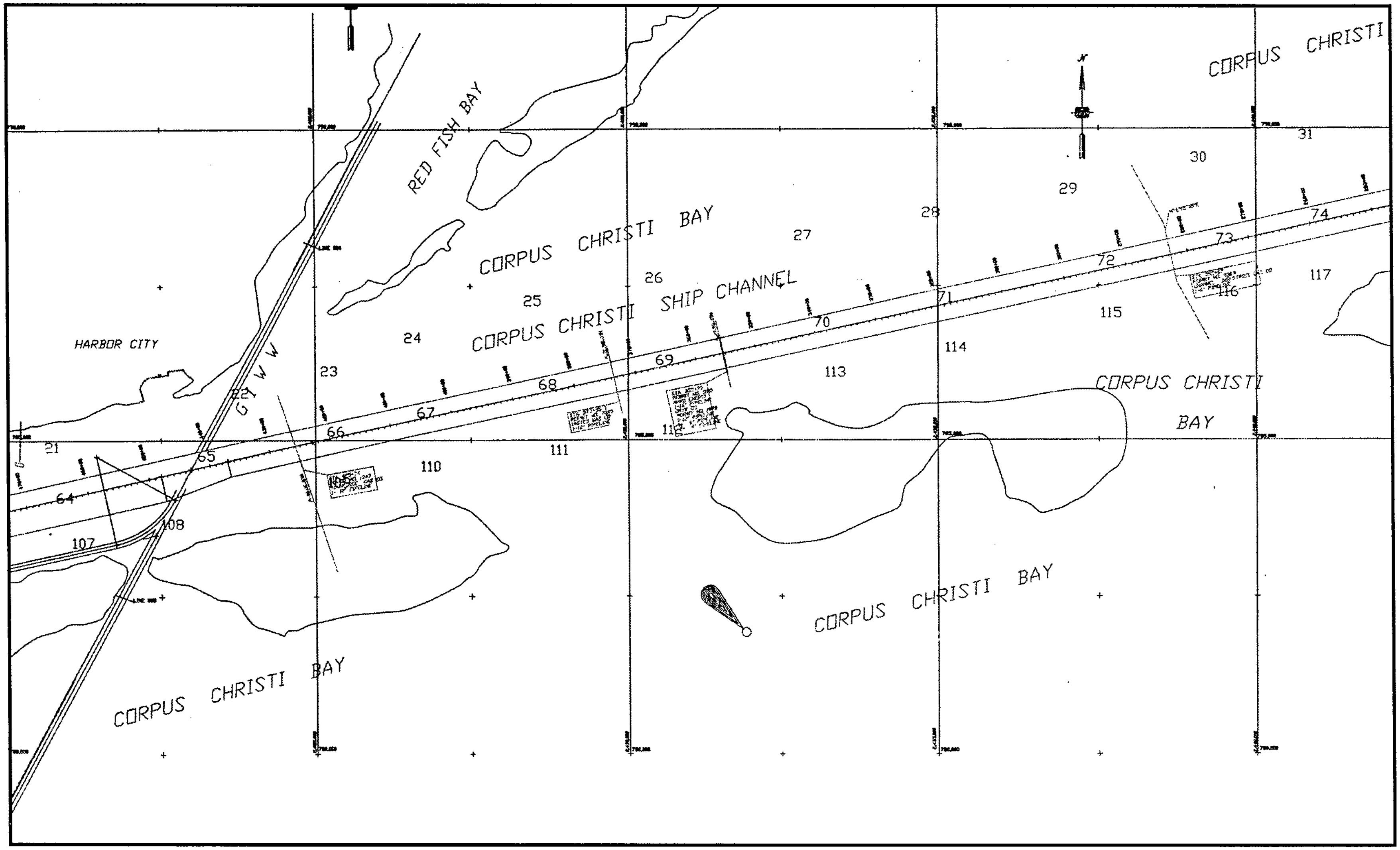


Figure 18. (Sheet 6 of 9)

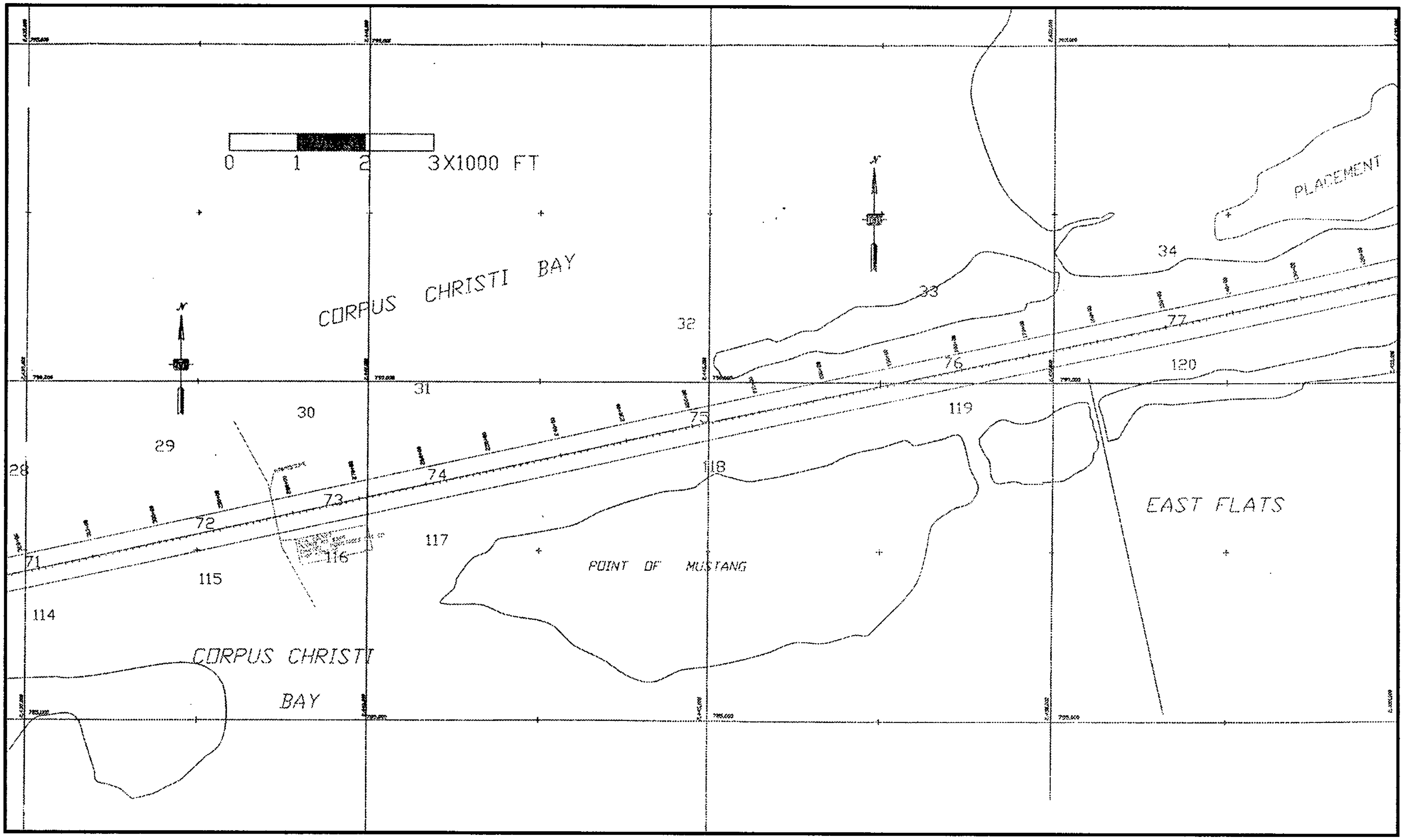


Figure 18. (Sheet 7 of 9)

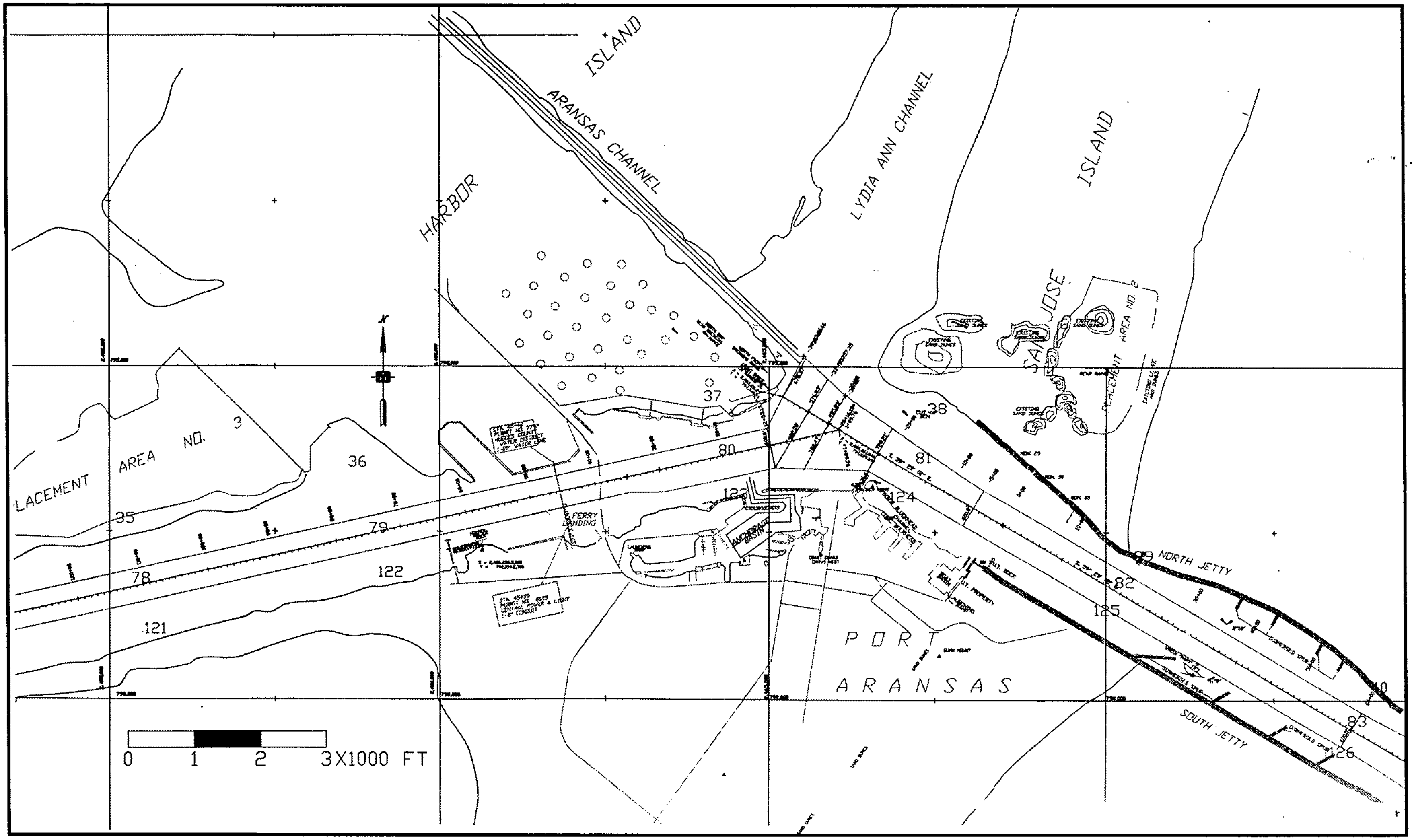


Figure 18. (Sheet 8 of 9)

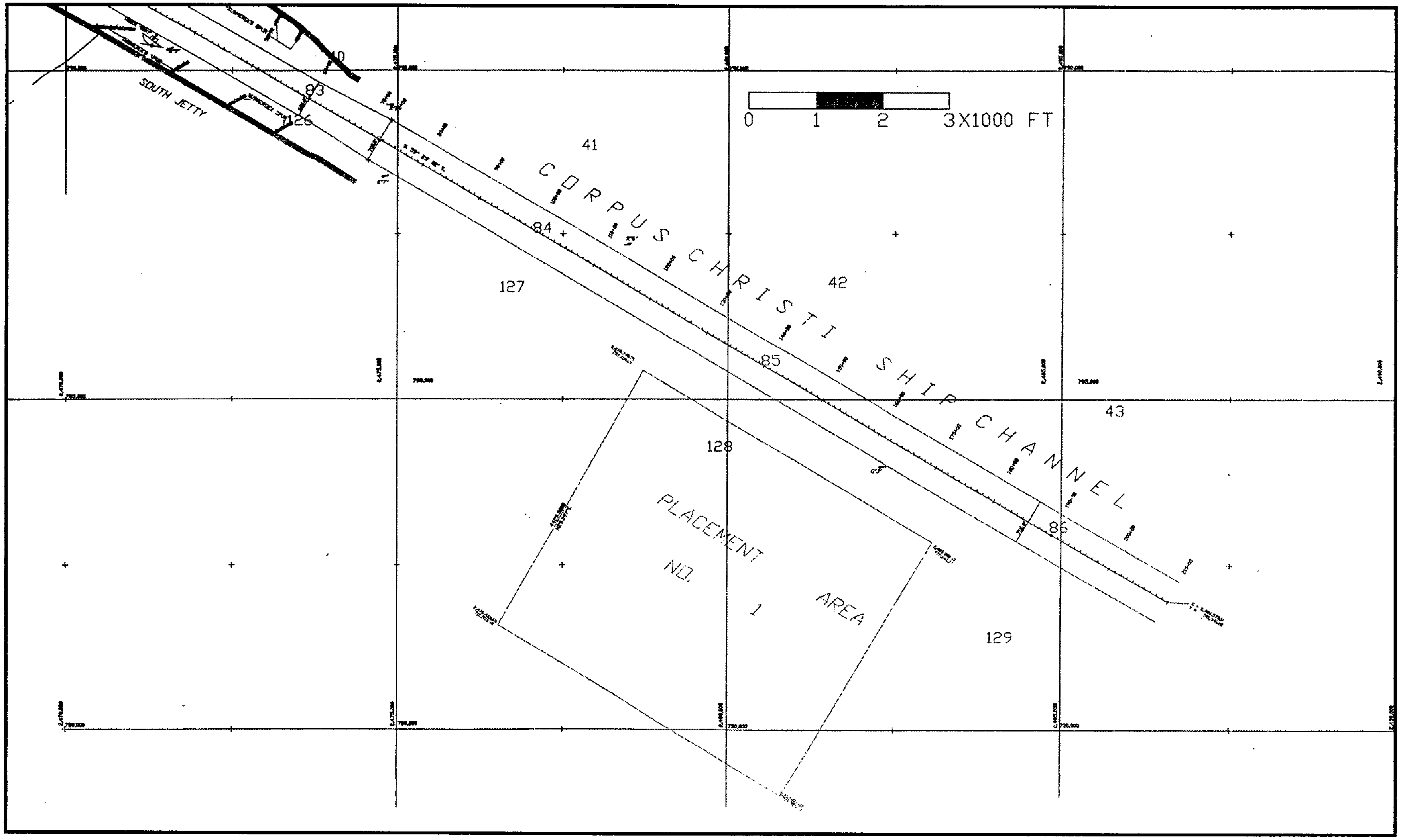


Figure 18. (Sheet 9 of 9)

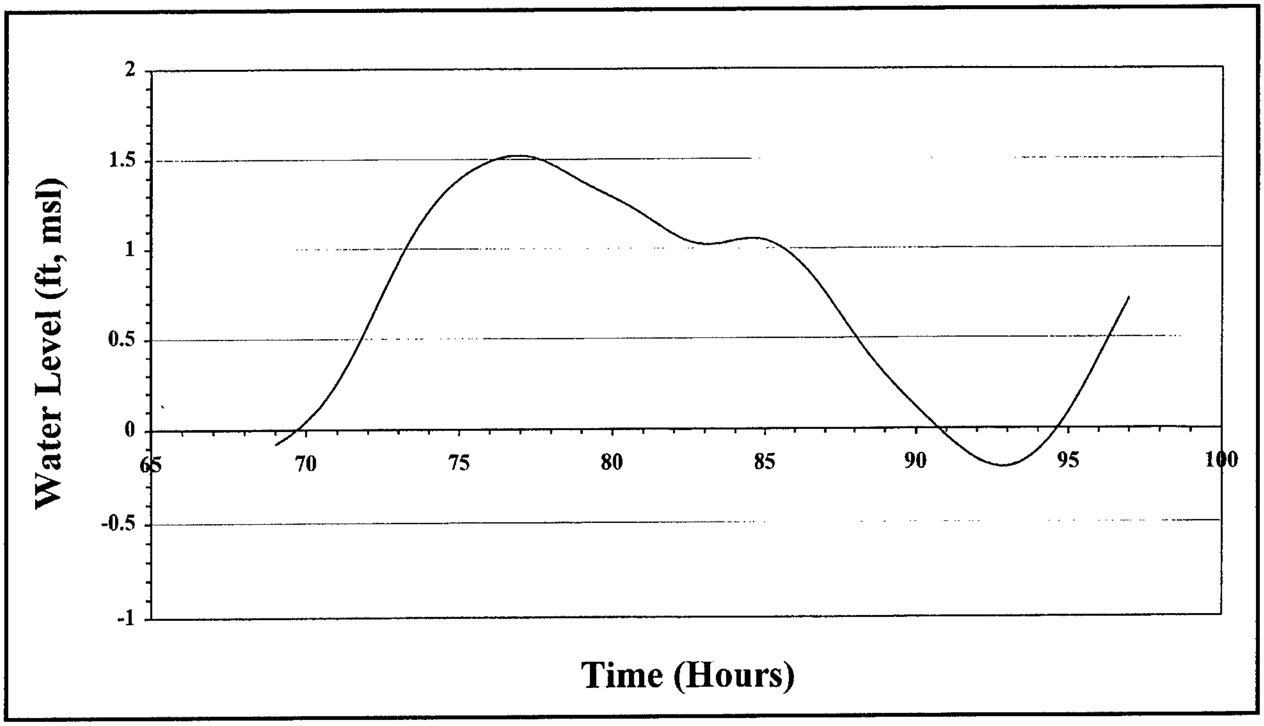


Figure 19. June tide at Bob Hall used in model with southeast wind, 69 hr to 96.5 hr (To convert feet to meters, multiply by 0.3048)

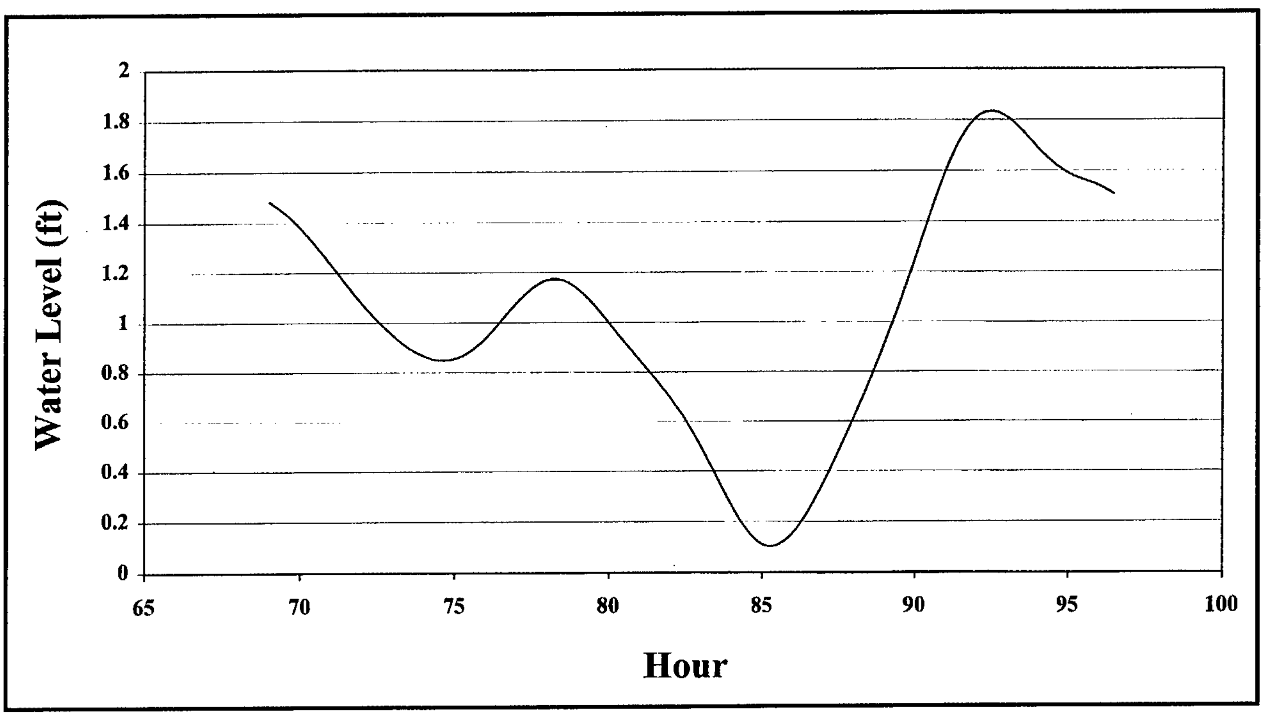


Figure 20. October tide at Bob Hall used in model with north wind, 69 hr to 96.5 hr

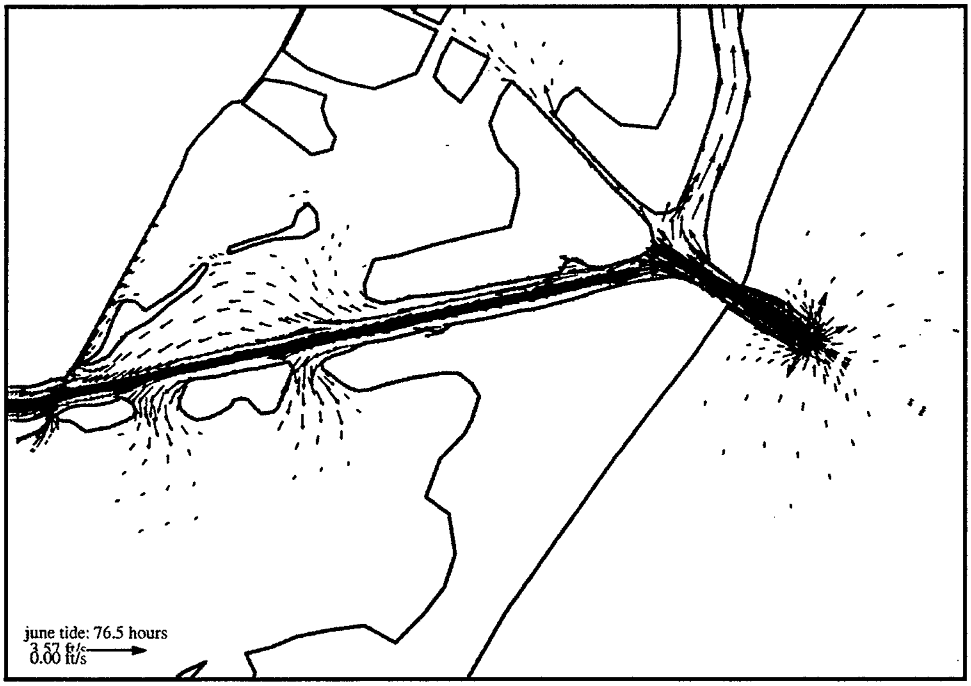


Figure 21. Flow pattern on numerical model for June tide flood near entrance area (To convert feet per second to meters per second, multiply by 0.3048)

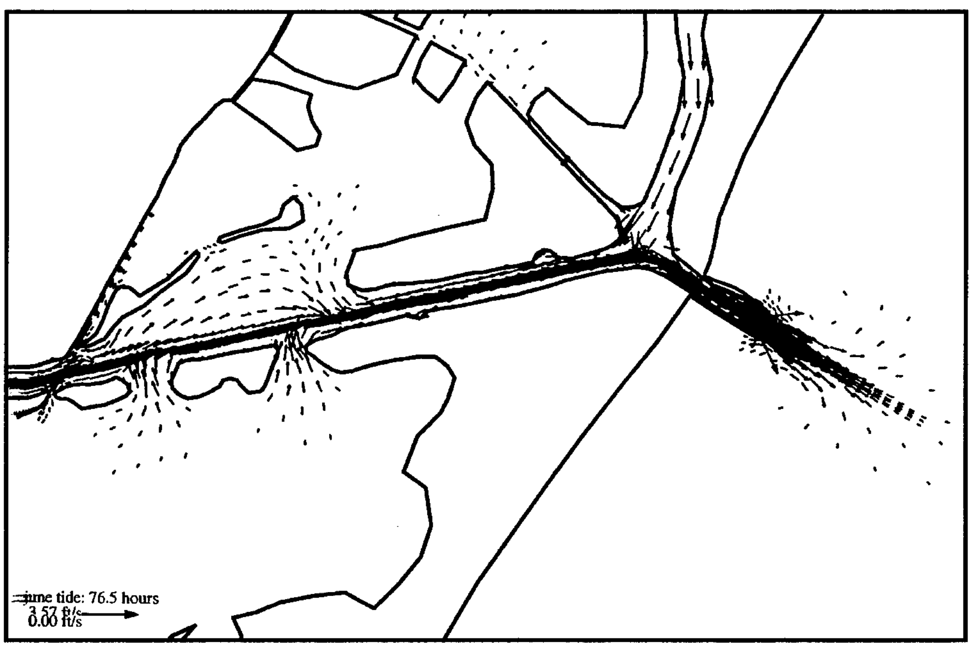


Figure 22. Flow pattern on numerical model for June tide ebb near entrance area

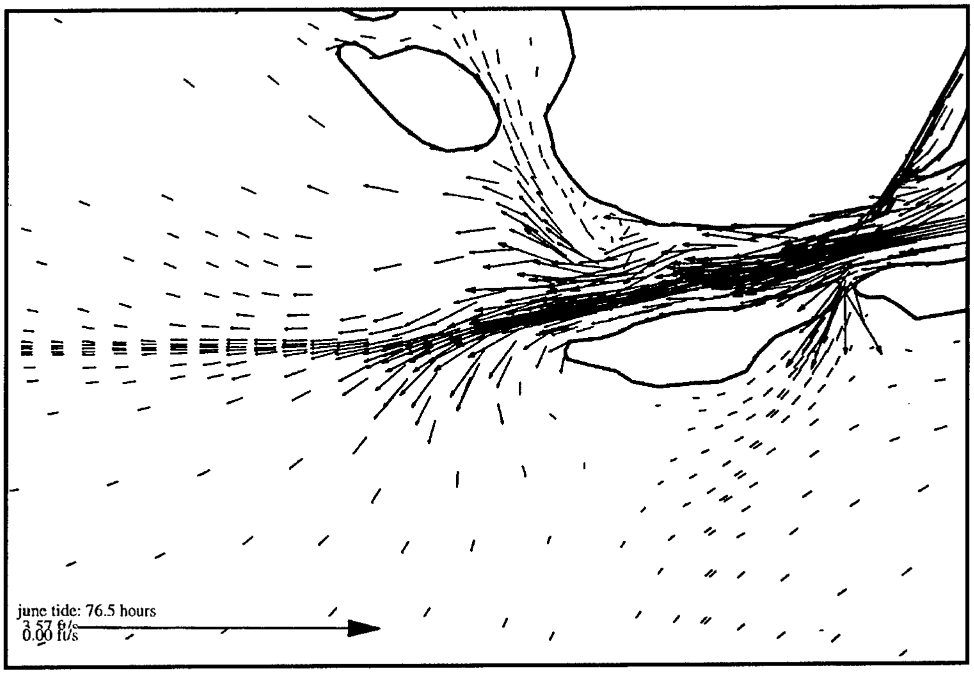


Figure 23. Flow pattern on numerical model for June tide flood in eastern bay area

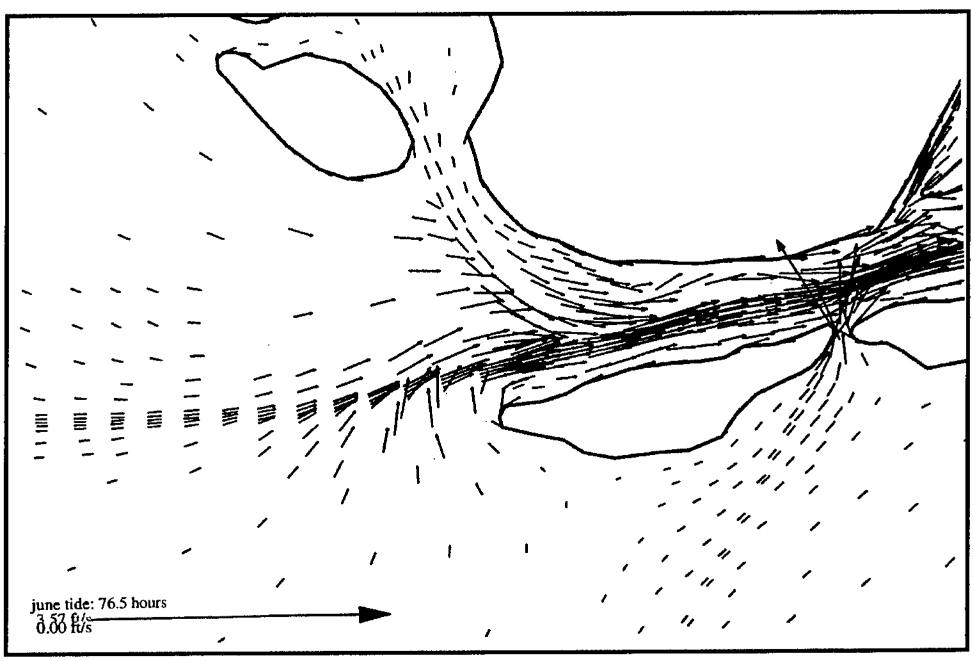


Figure 24. Flow pattern on numerical model for June tide ebb in eastern bay area

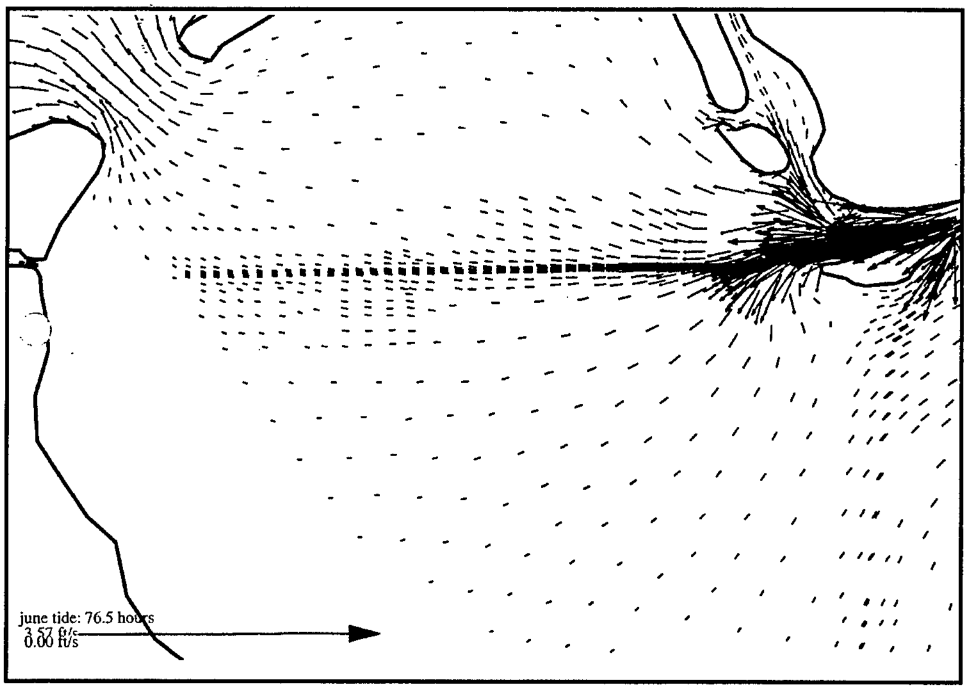


Figure 25. Flow pattern on numerical model to June tide flood in bay area

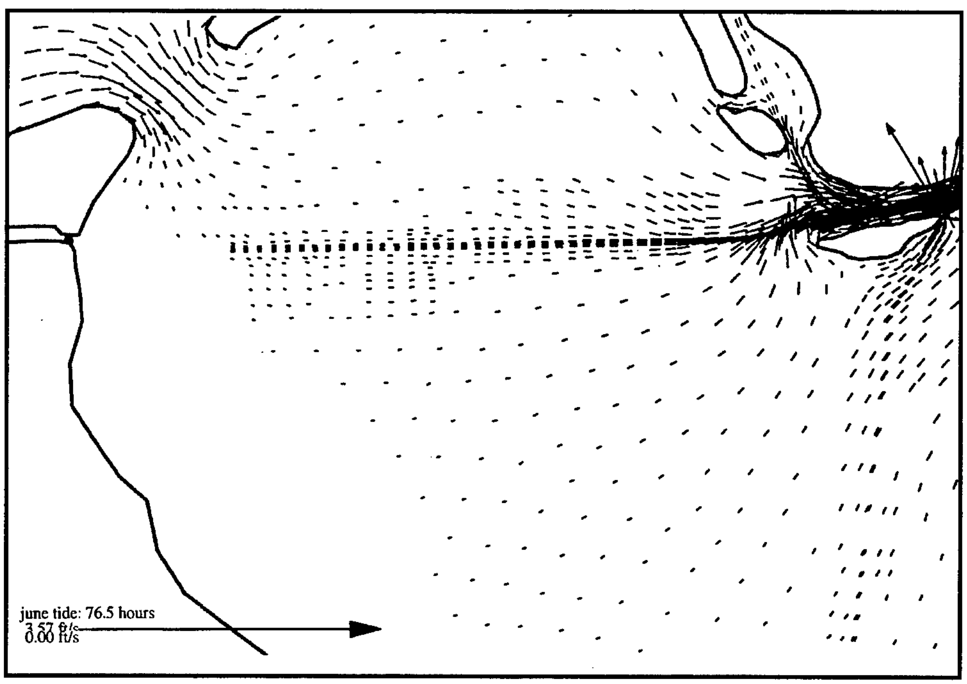


Figure 26. Flow pattern on numerical model for June tide ebb in bay area

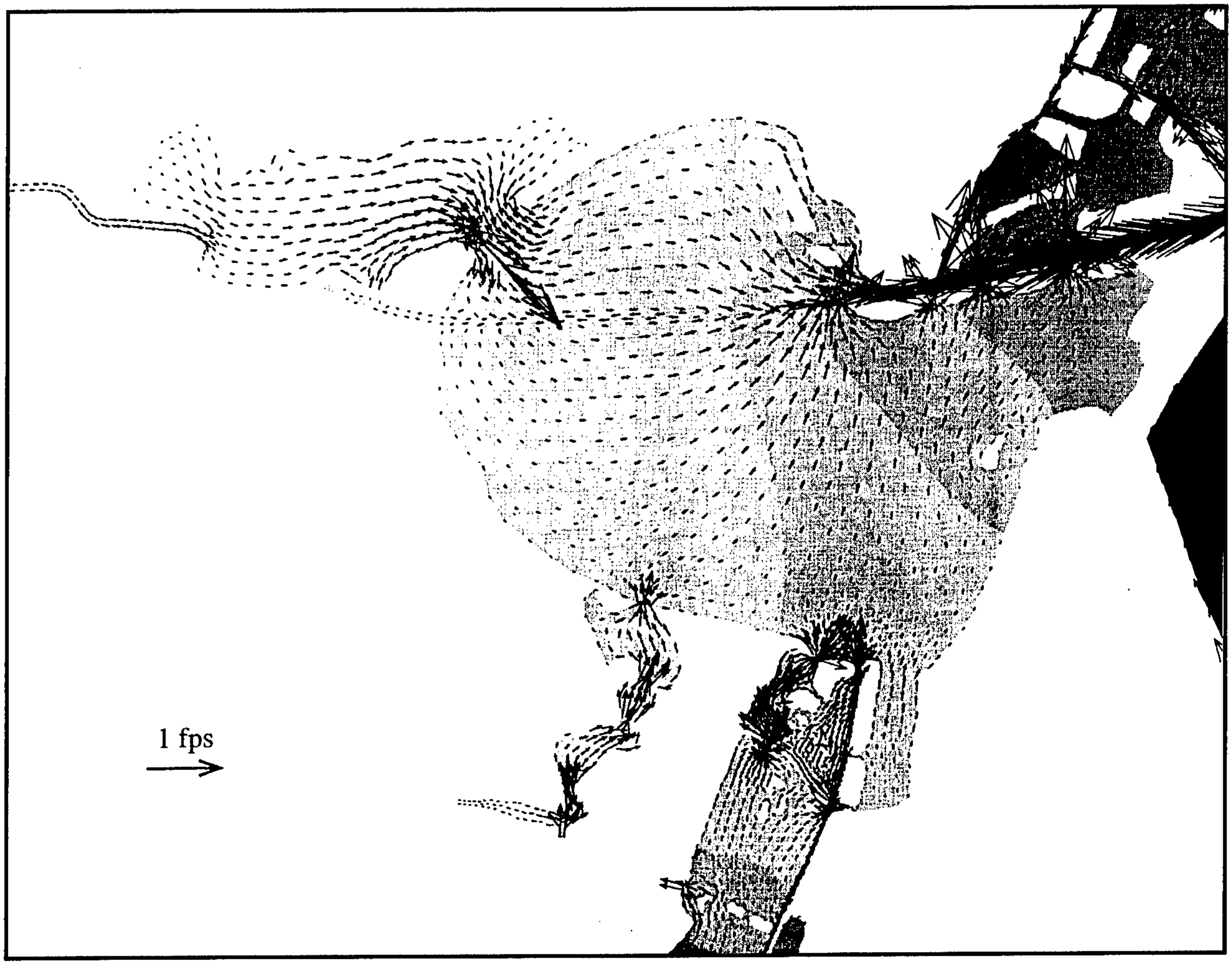


Figure 27. Flow pattern in TWDB numerical model in the bay area with 1-ft tide (Powell, Matsumoto, and Longley 1997)

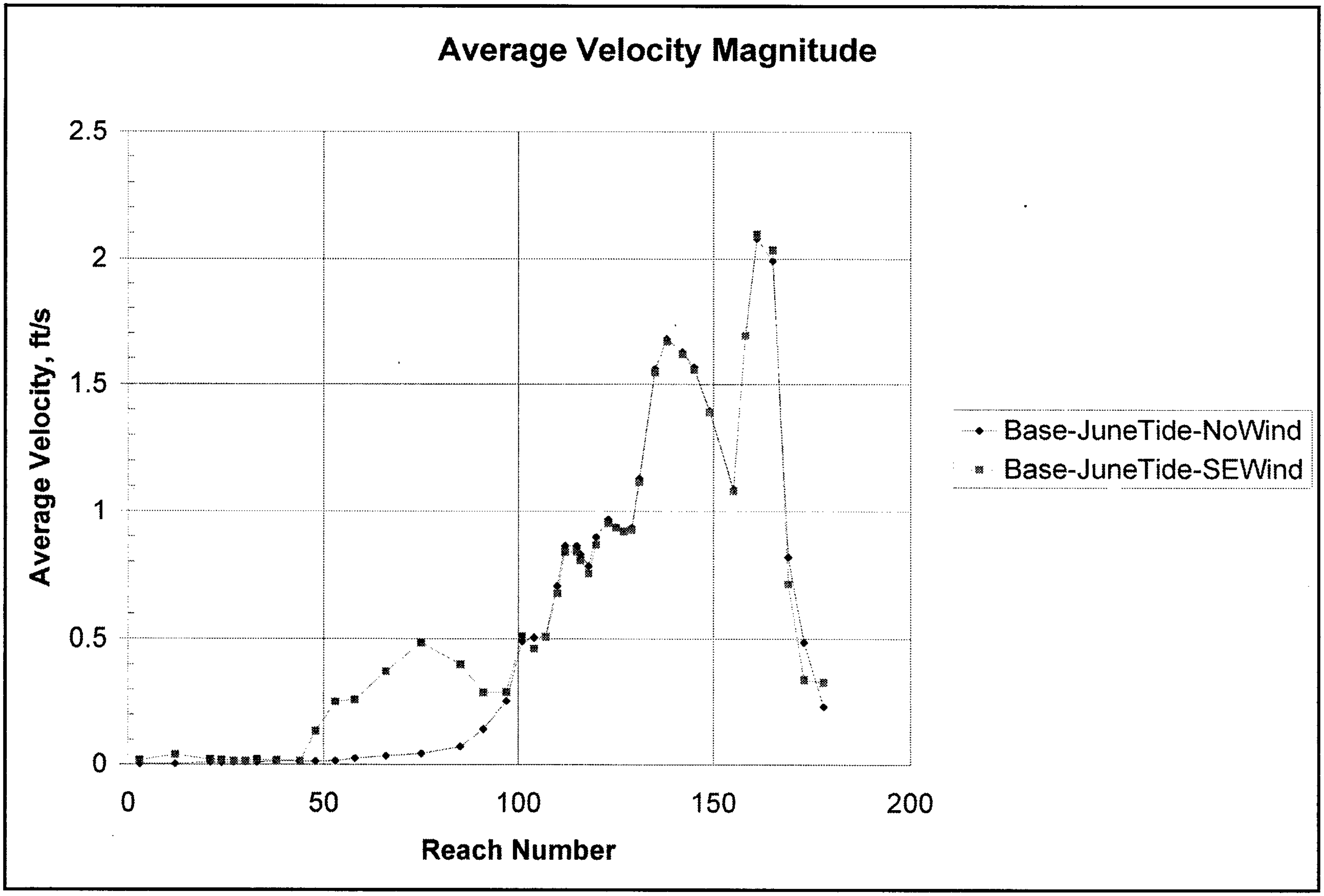


Figure 28. Average velocity magnitude, base condition, June tide, no wind and southeast wind (To convert feet per second to meters per second, multiply by 0.3048)

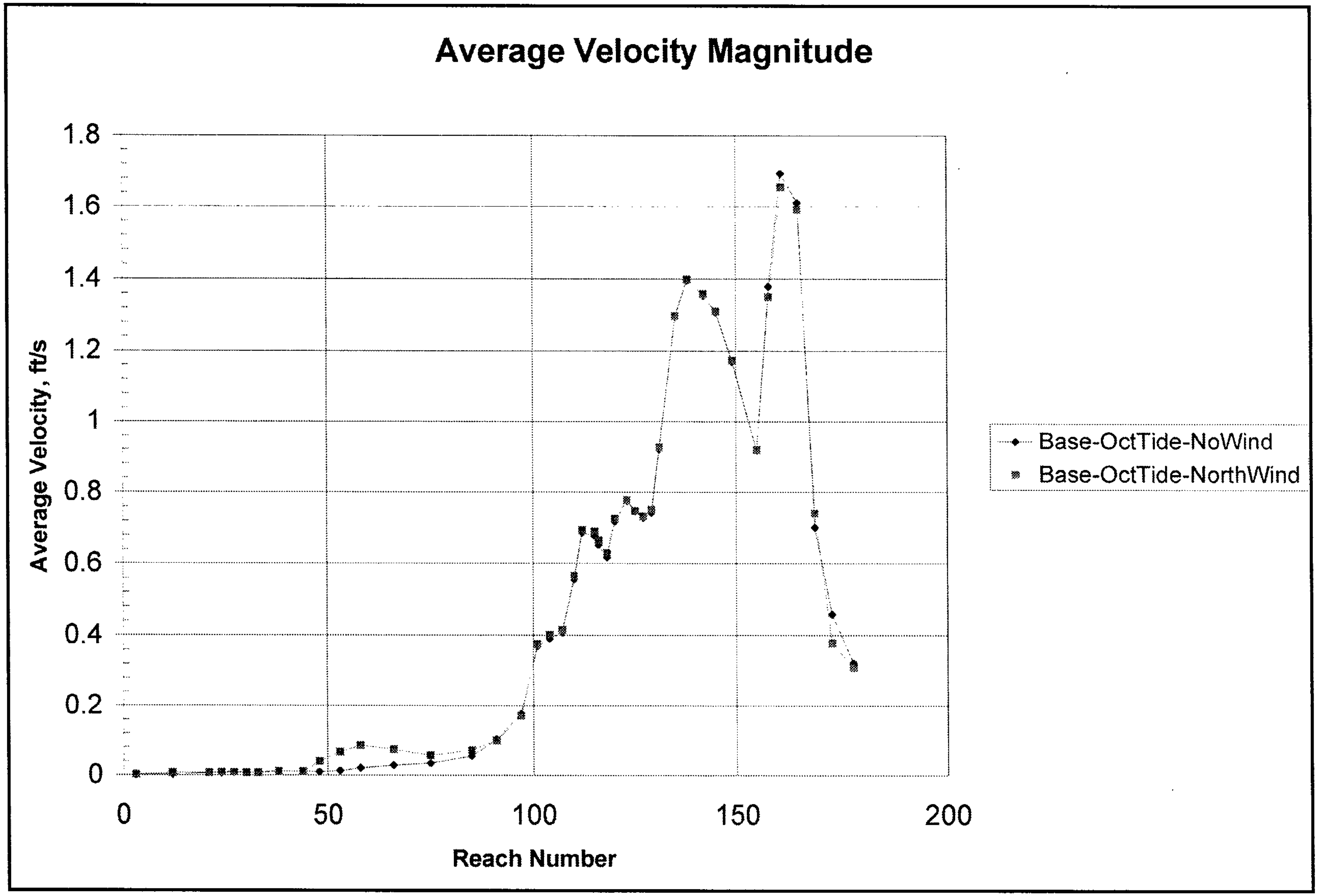


Figure 29. Average velocity magnitude, base condition, October tide, no wind and north wind (To convert feet per second to meters per second, multiply by 0.3048)

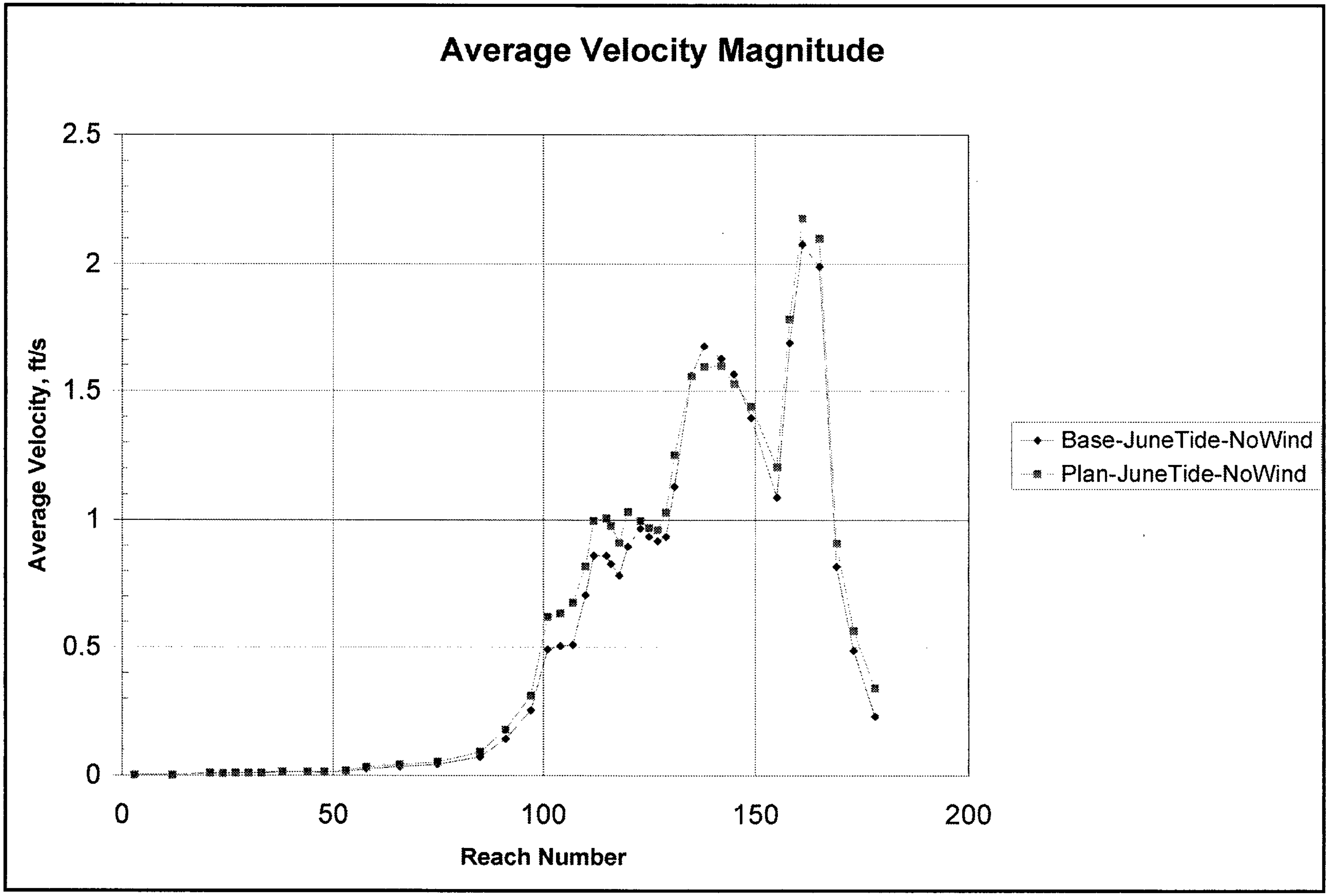


Figure 30. Average velocity magnitude, base and plan condition, June tide, no wind (To convert feet per second to meters per second, multiply by 0.3048)

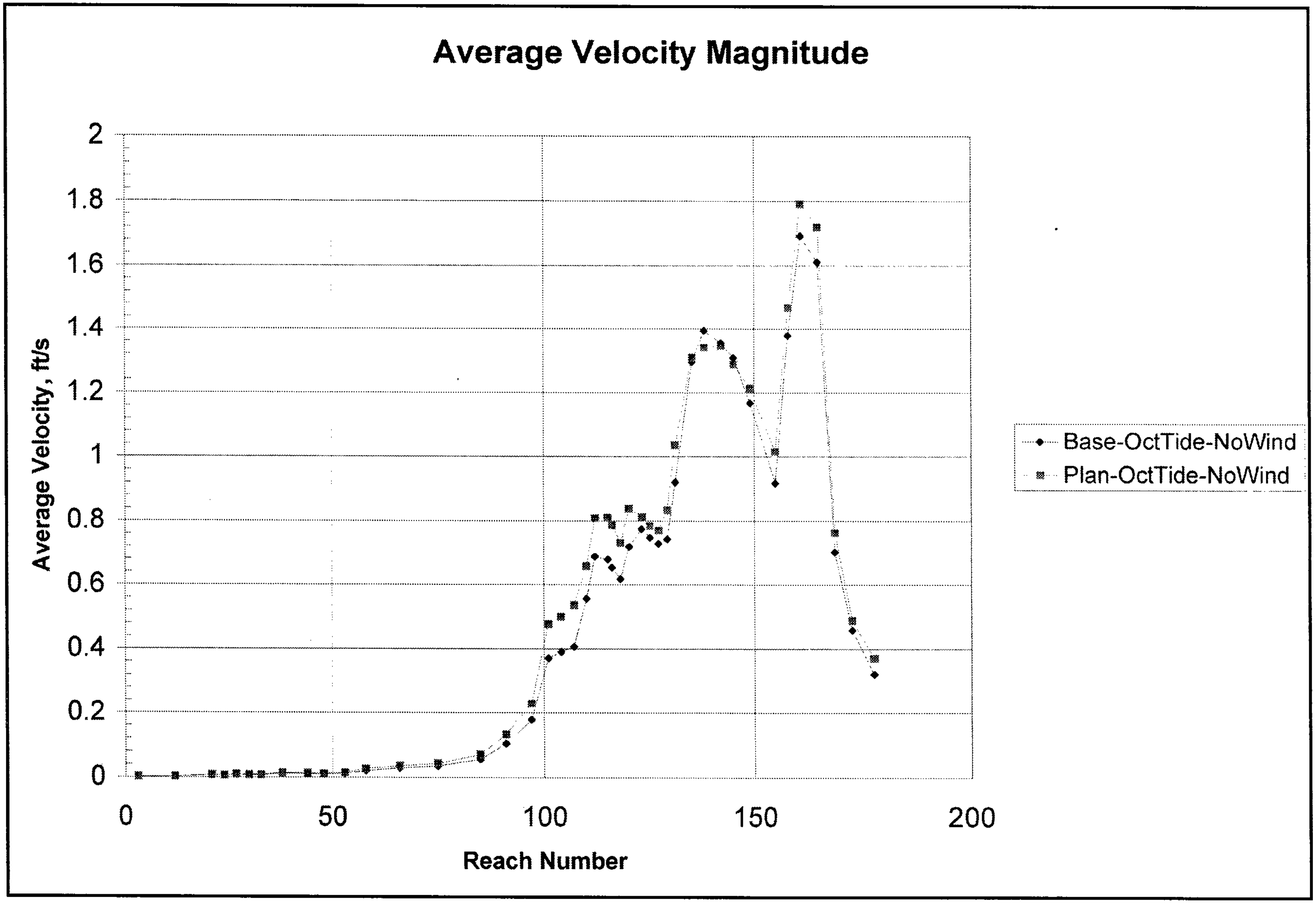


Figure 31. Average velocity magnitude, base and plan condition, October tide, no wind (To convert feet per second to meters per second, multiply by 0.3048)

Table 1
Coordinates, Instrumentation, and Sensor Location of Corpus Christi Bay Stations (Conrad Blucher Institute Report 2000)

Station	Latitude N	Longitude W	Instruments	Depth of Sensors (below water surface)
CC-Bay	27° 48' 00.12447"	97° 21' 12.66330"	Smart Sensor (AML0) Smart Sensor (AML1) Sontek (ADV)	6 ft 3 ft 3 ft
Titanic	27° 48' 02.55348"	97° 21' 42.54646"	Smart Sensor (AML2)	4 ft
Andrea Doria	27° 47' 38.48918"	97° 21' 18.64762"	Smart Sensor (AML3)	4 ft
CC-Bay 4	27° 45' 02.90642"	97° 13' 04.27468"	Sontek (ADV) Hydrolab	10 ft 4 ft
CC-Bay 5	27° 48' 02.55348"	97° 11' 19.65061"	Sontek (ADV) Hydrolab	6 ft 4 ft

Note: Multiply by 0.3048 to convert feet to meters.

Table 2
Parameters Recorded and Time of Deployment of Each Instrument, (Conrad Blucher Institute Report 2000)

Station	Sensor	Parameter	Deployed	Retrieved
CC-Bay	AML0	Water temp, pressue, turbidity X, Y current velocity	August 1998	June 1999
	AML1	Water temp, pressue, turbidity X, Y current velocity	August 1998	June 1999
	Sonetek0	Current velocity X, Y, and Z	December 1998	June 1999
Titanic	AML2	Water temp, pressue, turbidity X, Y current velocity	September 1998	June 1999
Andrea Doria	AML3	Water temp, pressue, turbidity X, Y current velocity	October 1998	June 1999
CC-Bay4	Sontek4	Current velocity X, Y, and Z	December 1998	June 1999
	Hydrolab4	Water temp, conductivity, salinity	December 1998	June 1999
CC-Bay5	Sontek5	Current, velocity X, Y, and Z	December 1998	June 1999
	Hydrolab5	Water temp, conductivity, salinity	December 1998	June 1999

Table 3
Titles Used for Different Reaches and Zones of Corpus Christi Navigation Channel

Section	Reach	Title of Zone	Zone
1 to 52	1 to 51	Harbor Channel	1
52 to 98	52 to 97	Open CC Bay Channel	2
98 to 118	98 to 117	Ingleside Channel	3
118 to 135	118 to 134	Redfish Bay Channel	4
135 to 156	135 to 155	Harbor Island Channel	5
156 to 166	156 to 165	Inner Channel	6
166 to 181	166 to 180	Outer Channel	7

Table 4
Correlation Between District Notation, Section Number, Reach Number, and Zone Name for the Corpus Christi Navigation Channel Study

District Notation	Section	Reach	Distance ft	Distance miles	Zone
1560	1		0	0	1
1550	2	1	1000	0.1893939	
1540	3	2	2000	0.3787879	
1530	4	3	3000	0.5681818	
1520	5	4	4000	0.7575758	
1510	6	5	5000	0.9469697	
1500	7	6	6000	1.1363636	
1490	8	7	7000	1.3257576	
1480	9	8	8000	1.5151515	
1470	10	9	9000	1.7045455	
1460	11	10	10000	1.8939394	
1450	12	11	11000	2.0833333	
1440	13	12	12000	2.2727273	
1430	14	13	13000	2.4621212	
1420	15	14	14000	2.6515152	
1410	16	15	15000	2.8409091	
1400	17	16	16000	3.030303	
1390	18	17	17000	3.219697	
1380	19	18	18000	3.4090909	
1370	20	19	19000	3.5984848	
1360	21	20	20000	3.7878788	
1350	22	21	21000	3.9772727	
1340	23	22	22000	4.1666667	
1330	24	23	23000	4.3560606	
1320	25	24	24000	4.5454545	
1310	26	25	25000	4.7348485	
1300	27	26	26000	4.9242424	
1290	28	27	27000	5.1136364	
1280	29	28	28000	5.3030303	
1270	30	29	29000	5.4924242	
1260	31	30	30000	5.6818182	
1250	32	31	31000	5.8712121	
1240	33	32	32000	6.0606061	
1230	34	33	33000	6.25	
1220	35	34	34000	6.4393939	
1210	36	35	35000	6.6287879	
1200	37	36	36000	6.8181818	
1190	38	37	37000	7.0075758	
1180	39	38	38000	7.1969697	

(Sheet 1 of 5)

Notes:
1. Zero distance reference used by the Galveston District is at the landward end of south jetty.
2. Center lines of inner and outer channel meet at Intersection (Section 157)
3. Multiply by 0.3048 to convert feet into meters.

Table 4 (Continued)					
District Notation	Section	Reach	Distance ft	Distance miles	Zone
1170	40	39	39000	7.3863636	1 (cont)
1160	41	40	40000	7.5757576	
1150	42	41	41000	7.7651515	
1140	43	42	42000	7.9545455	
1130	44	43	43000	8.1439394	
1120	45	44	44000	8.3333333	
1110	46	45	45000	8.5227273	
1100	47	46	46000	8.7121212	
1090	48	47	47000	8.9015152	
1080	49	48	48000	9.0909091	
1070	50	49	49000	9.280303	
1060	51	50	50000	9.469697	
1050	52	51	51000	9.6590909	
1040	53	52	52000	9.8484848	2
1030	54	53	53000	10.037879	
1020	55	54	54000	10.227273	
1010	56	55	55000	10.416667	
1000	57	56	56000	10.606061	
990	58	57	57000	10.795455	
980	59	58	58000	10.984848	
970	60	59	59000	11.174242	
960	61	60	60000	11.363636	
950	62	61	61000	11.55303	
940	63	62	62000	11.742424	
930	64	63	63000	11.931818	
920	65	64	64000	12.121212	
910	66	65	65000	12.310606	
900	67	66	66000	12.5	
890	68	67	67000	12.689394	
880	69	68	68000	12.878788	
870	70	69	69000	13.068182	
860	71	70	70000	13.257576	
850	72	71	71000	13.44697	
840	73	72	72000	13.636364	
830	74	73	73000	13.825758	
820	75	74	74000	14.015152	
810	76	75	75000	14.204545	
800	77	76	76000	14.393939	
790	78	77	77000	14.583333	
780	79	78	78000	14.772727	
770	80	79	79000	14.962121	
760	81	80	80000	15.151515	
750	82	81	81000	15.340909	
740	83	82	82000	15.530303	

(Sheet 2 of 5)

Table 4 (Continued)

District Notation	Section	Reach	Distance ft	Distance miles	Zone
730	84	83	83000	15.719697	2 (cont)
720	85	84	84000	15.909091	
710	86	85	85000	16.098485	
700	87	86	86000	16.287879	
690	88	87	87000	16.477273	
680	89	88	88000	16.666667	
670	90	89	89000	16.856061	
660	91	90	90000	17.045455	
650	92	91	91000	17.234848	
640	93	92	92000	17.424242	
630	94	93	93000	17.613636	
620	95	94	94000	17.80303	
610	96	95	95000	17.992424	
600	97	96	96000	18.181818	
590	98	97	97000	18.371212	
580	99	98	98000	18.560606	3
570	100	99	99000	18.75	
560	101	100	100000	18.939394	
550	102	101	101000	19.128788	
540	103	102	102000	19.318182	
530	104	103	103000	19.507576	
520	105	104	104000	19.69697	
510	106	105	105000	19.886364	
500	107	106	106000	20.075758	
490	108	107	107000	20.265152	
480	109	108	108000	20.454545	
470	110	109	109000	20.643939	
460	111	110	110000	20.833333	
450	112	111	111000	21.022727	
440	113	112	112000	21.212121	
430	114	113	113000	21.401515	
420	115	114	114000	21.590909	
410	116	115	115000	21.780303	
400	117	116	116000	21.969697	
390	118	117	117000	22.159091	
380	119	118	118000	22.348485	4
370	120	119	119000	22.537879	
360	121	120	120000	22.727273	
350	122	121	121000	22.916667	
340	123	122	122000	23.106061	
330	124	123	123000	23.295455	
320	125	124	124000	23.484848	

(Sheet 3 of 5)

Table 4 (Continued)

District Notation	Section	Reach	Distance ft	Distance miles	Zone
310	126	125	125000	23.674242	4 (cont)
300	127	126	126000	23.863636	
290	128	127	127000	24.05303	
280	129	128	128000	24.242424	
270	130	129	129000	24.431818	
260	131	130	130000	24.621212	
250	132	131	131000	24.810606	
240	133	132	132000	25	
230	134	133	133000	25.189394	
220	135	134	134000	25.378788	
210	136	135	135000	25.568182	5
200	137	136	136000	25.757576	
190	138	137	137000	25.94697	
180	139	138	138000	26.136364	
170	140	139	139000	26.325758	
160	141	140	140000	26.515152	
150	142	141	141000	26.704545	
140	143	142	142000	26.893939	
130	144	143	143000	27.083333	
120	145	144	144000	27.272727	
110	146	145	145000	27.462121	
100	147	146	146000	27.651515	
90	148	147	147000	27.840909	
80	149	148	148000	28.030303	
70	150	149	149000	28.219697	
60	151	150	150000	28.409091	
50	152	151	151000	28.598485	
40	153	152	152000	28.787879	
30	154	153	153000	28.977273	
20	155	154	154000	29.166667	
10	156	155	155000	29.356061	
Intersection	157	156	155800	29.507576	6
-20	158	157	156600	29.659091	
-10	159	158	157600	29.848485	
0	160	159	158600	30.037879	
10	161	160	159600	30.227273	
20	162	161	160600	30.416667	
30	163	162	161600	30.606061	
40	164	163	162600	30.795455	
50	165	164	163600	30.984848	
60	166	165	164600	31.174242	

(Sheet 4 of 5)

Table 4 (Concluded)					
District Notation	Section	Reach	Distance ft	Distance miles	Zone
70	167	166	165600	31.363636	7
80	168	167	166600	31.55303	
90	169	168	167600	31.742424	
100	170	169	168600	31.931818	
110	171	170	169600	32.121212	
120	172	171	170600	32.310606	
130	173	172	171600	32.5	
140	174	173	172600	32.689394	
150	175	174	173600	32.878788	
160	176	175	174600	33.068182	
170	177	176	175600	33.257576	
180	178	177	176600	33.44697	
190	179	178	177600	33.636364	
200	180	179	178600	33.825758	
210	181	180	179600	34.015152	

(Sheet 5 of 5)

Table 5
Monthly Predominant Wind Directions Observed During July 1972 to June 1973

Month	Predominant Wind Direction
January	N
February	NE
March	SSE
April	SE
May	SE
June	SE
July	SE
August	SSE
September	SSE
October	SSE
November	NNE
December	N

Table 6
Locations of Bed Samples In Different Reaches of Navigation Channel

Bed Sample	Section	Reach	Zone	Title of Zone
None	1 to 52	1 to 51	1	Harbor Channel
1 through 78	52 to 98	52 to 97	2	Open CC Bay Channel
79 through 85	98 to 118	98 to 117	3	Ingleside Channel
86, 87, 88	118 to 135	118 to 134	4	Redfish Bay Channel
89, 90, 91, 92, 93	135 to 156	135 to 155	5	Harbor Island Channel
94, 95	156 to 166	156 to 165	6	Inner Channel
None	166 to 181	166 to 181	7	Outer Channel

Table 7
Percentage Fraction of Sand and Silt Plus Clay in Navigation Channel

(Sand) and (Silt plus Clay) Separation analysis
Project: Corpus Christi: Sampling date: 8/15, 16, &17/00

Location Number	Sediment Type	Net Weight g	Total Sediment Weight, g	Percent of Fraction	Shell[1] %
Zone 2					
7	sand	0.3	4.42	6.79	12.50
	silt/clay	4.12		93.21	
10	sand	0.08	4.05	1.98	3.55
	silt/clay	3.97		98.02	
13	sand	0.02	4.36	0.46	6.64
	silt/clay	4.34		99.54	
48	sand	0.06	5.56	1.08	1.94
	silt/clay	5.5		98.92	
56	sand	0.17	6.10	2.79	8.27
	silt/clay	5.93		97.21	
75	sand	0.78	7.82	9.97	5.62
	silt/clay	7.04		90.03	
Zone 3					
87	sand	11.61	12.94	89.72	23.30
	silt/clay	1.33		10.28	
Zone 4					
88	sand	8.31	8.91	93.27	28.59
	silt/clay	0.6		6.73	
89	sand	2.89	7.81	37.00	29.58
	silt/clay	4.92		63.00	
Zone 5					
90	sand	9.24	9.65	95.75	20.40
	silt/clay	0.41		4.25	
91	sand	14.22	14.71	96.67	9.08
	silt/clay	0.49		3.33	
92	sand	8.63	8.79	98.18	30.38
	silt/clay	0.16		1.82	
93	sand	7.87	10.58	74.39	9.19
	silt/clay	2.71		25.61	

[1] Shell weight was not included in the sand-silt/clay separation analysis or sieve analysis.

Table 8
Percentage Fraction of Sand and Silt Plus Clay in Placement Areas

(Sand) & (Silt plus Clay) Separation analysis
Project: Corpus Christi: Sampling date: 8/15,16&17/00

Location Number	Sediment Type	Net Weight g	Total Sediment Weight, g	Percent of Fraction	Shell[1] %
Placement Areas Near Zone 2 of the Navigation Channel					
8	sand	1.26	2.51	50.20	85.45
	silt/clay	1.25		49.80	
11	sand	1.09	3.80	28.68	74.85
	silt/clay	2.71		71.32	
14	sand	0.1	1.11	9.01	92.35
	silt/clay	1.01		90.99	
23	sand	0.16	4.18	3.83	37.54
	silt/clay	4.02		96.17	
28	sand	5.94	6.49	91.53	0.92
	silt/clay	0.55		8.47	
34	sand	4.43	5.27	84.06	24.68
	silt/clay	0.84		15.94	
35	sand	11.67	13.00	89.77	9.06
	silt/clay	1.33		10.23	
46	sand	0.99	2.90	34.14	66.28
	silt/clay	1.91		65.86	
58	sand	5.97	7.08	84.32	15.11
	silt/clay	1.11		15.68	
70	sand	7.82	12.77	61.24	8.19
	silt/clay	4.95		38.76	
76	sand	12.86	13.19	97.50	2.41
	silt/clay	0.33		2.50	

[1] Shell weight was not included in the sand-silt/clay separation analysis or sieve analysis.

Table 9
Bulk Density of Selected Bed Samples Measured by Using Pycno Bottles

Project Name: Corpus Christi
Project Sampling Date: Aug. 2000

Pycno Bottle	Location	Temp. C	Tare	Weight bottle + sed	Weight bottle +sed +water	Density water	Volume pycno bottle	Sediment Density g/cm^3
Samples from Navigation Channel								
202	3	22	29.6814	42.6651	56.9434	0.998	24.9954	1.215
202	48	22	29.6816	38.8893	56.8444	0.998	24.9954	1.315
205	49	22	28.3946	40.8120	56.8023	0.998	24.9413	1.392
205	72	22	28.3942	41.9685	55.6102	0.998	24.9413	1.204
Samples from Sediment Placement Areas								
208	8[1]	22	27.3685	42.3412	58.4464	0.998	24.9842	1.692
209	11[2]	22	27.9252	41.1268	59.0366	0.998	25.3639	1.780
3	14[2]	22	36.5226	51.5869	67.9200	0.998	25.0280	1.739
4	23[1]	22	36.6201	50.1945	65.0220	0.998	24.7690	1.870
6	34[1]	22	36.5594	57.9403	70.8790	0.998	24.5560	1.845
7	46[1]	22	36.8385	50.9969	64.3050	0.998	24.1670	1.807
8	58[1]	22	36.3923	59.1736	71.9520	0.998	24.7870	1.901
202	70[2]	22	29.6811	44.2085	61.6160	0.998	24.9954	1.923

[1] Lot of shell.
[2] Mostly shell.

Table 10
Loss on Ignition Test Performed on Selected Samples

Project: Corpus Christi: Loss on ignition
Project sampling date: Aug. 2000

Sta	Crucible Tare Wt. g	Dry Sed. + Crucible Wt., g	Dry Sed. Wt., g	Fired Sed. Wt.+ Crucible, g	Ash Wt., g	Loss on Ignition %
1	8.7668	11.369	2.6022	11.1045	2.3377	10.16
9	9.6631	12.9106	3.2475	12.6918	3.0287	6.74
41	9.3854	14.5707	5.1853	14.2903	4.9049	5.41
60	9.324	12.8607	3.5367	12.5087	3.1847	9.95

Table 11
Results of Analysis of Water Samples Collected in Navigation Channel

Field Location	Revised Location	Sampling Date	Sampling Time	Salinity ppt	Depth ft	Susp. Conc mg/L	Reach	Channel Zone
Zone 2								
1.0	1	8/15/00	0944	39.30	22.5	35	52	2
1.1	2		0951	39.39	24.5	88	52	2
1.2	3		1000	39.36	25.5	46	53	2
1.3	4		1012	39.32	20.5	37	53	2
2.0	6		1018	39.36	22.5	47	54	2
2.2	7		1509	39.11	27.0	21	60	2
3.0	9		1458	39.12	25.0	24	61	2
3.2	10		1452	39.19	27.0	22	62	2
4.0	12		1441	39.08	26.5	23	63	2
4.2	13		1437	39.07	26.5	22	65	2
5.0	15		1423	39.02	26.0	21	66	2
5.2	16		1419	39.20	24.0	34	67	2
6.0	17		1415	39.24	24.0	27	69	2
6.2	18		1411	39.34	25.0	21	70	2
7.0	20		1402	39.29	26.0	31	71	2
7.2	21		1346	39.31	29.5	26	72	2
8.0	24		1332	39.33	25.0	27	74	2
8.1	25		1242	39.18	17.8	40	74	2
8.2	26		1328	39.36	26.0	32	75	2
8.3	27		1237	39.20	23.5	28	75	2
9.0	30		1313	39.30	27.5	28	76	2
9.2	32		1308	39.30	24.5	19	77	2
9.3	33		1219	39.22	18.0	48	78	2
10.0	36		1248	39.28	21.0	33	79	2
10.1	37		1414	39.23	22.0	23	79	2
10.2	38	8/16/00	1242	39.27	24.0	35	80	2
10.3	39		1134	39.22	23.5	38	81	2
11.0	42		1226	39.27	27.0	26	81	2
11.1	43		1128	39.28	24.0	43	82	2
11.2	44		1221	39.21	26.5	20	82	2
11.3	45		1120	39.19	25.0	63	83	2
12.0	48		1206	39.26	27.0	32	84	2
12.1	49		1338	39.26	26.5	35	84	2
12.2	50		1201	39.23	27.0	33	85	2

(Continued)

Note: Multiply by 0.3048 to convert feet to meters.

Table 11 (Concluded)								
Field Location	Revised Location	Sampling Date	Sampling Time	Salinity ppt	Depth ft	Susp. Conc mg/L	Reach	Channel Zone
Zone 2 (Continued)								
12.3	51	8/16/00	1330	39.23	24.5	42	85	2
13.0	54		1144	39.19	25.0	61	86	2
13.1	55		1323	39.23	26.5	38	87	2
13.2	56		NA	39.19	21.0	31	87	2
13.3	57		1315	39.18	26.5	26	88	2
14.0	60		1120	39.21	26.5	37	89	2
14.1	61		1109	39.20	26.0	32	89	2
14.2	62		1105	39.25	26.2	41	90	2
14.3	63		1059	39.23	25.8	39	91	2
15.0	66		1037	39.26	26.0	38	91	2
15.1	67		1032	39.26	24.0	30	92	2
15.2	68		1021	39.33	25.5	29	93	2
15.3	69		0958	39.16	23.0	27	93	2
16.0	72		0950	39.14	23.5	21	94	2
16.1	73		0946	39.06	26.5	24	95	2
16.2	74		0936	39.17	18.0	36	95	2
16.3	75		0930	39.06	24.2	31	96	2
17.0	78		0902	39.11	27.5	35	97	2
Zone 3								
17.1	79	8/16/00	0857	39.07	25.5	38	97	3
17.2	80		0851	39.08	27.0	38	98	3
17.3	81		0845	39.05	26.5	39	99	3
18.0	84		0817	39.00	25.5	46	99	3
19.0	85		0809	38.93	26.0	36	102	3
20.0	86		1612	38.47	25.0	13	104	3
21.0	87		1924	38.32	16.5	16	115	3
Zone 4								
23.0	88	8/16/00	1919	38.33	22.5	15	120	4
27.0	89		1910	37.82	22.5	9	131	4
Zone 5								
29.0	90	8/16/00	1905	37.18	19.0	13	136	5
31.0	91		1855	36.89	28.0	16	141	5
33.0	92		1848	37.76	27.0	46	146	5
35.0	93		1838	36.96	25.5	13	151	5
Zone 6								
37.0	95	8/16/00	1827	36.76	28.5	17	158	6

Table 12
Results of Analysis of Water Samples Collected over Placement Areas

Field Location	Revised Location	Sampling Date	Sampling Time	Salinity ppt	Depth ft	Susp. Conc mg/L	Reach	Channel Zone
Water Samples Collected Over Placement Areas								
2.0A	5	"	1029	39.25	7.0	26	N. of 54	2
3.0B	8	"	1501	39.12	5.5	18	S. of 61	2
4.0B	11	"	1446	39.09	5.5	17	S. of 63	2
5.0B	14	"	1427	39.14	5.8	13	S. of 66	2
7.0B	19	"	1406	39.60	6.5	11	S. of 71	2
8.0A	22	"	1336	39.18	6.0	27	N. of 74	2
8.0B	23	"	1342	39.24	7.5	20	S. of 74	2
9.0A	28	"	1318	39.26	5.5	22	N. of 76	2
9.0B	29	"	1323	39.37	6.5	13	S. of 76	2
10.0A	34	"	1253	39.23	6.0	18	N. of 79	2
10.0B	35	"	1301	39.25	7.5	15	S. of 79	2
11.0A	40	"	1230	39.19	6.5	15	N. of 81	2
11.0B	41	"	1236	39.17	7.5	15	S. of 81	2
12.0A	46	"	1211	39.28	6.5	26	N. of 84	2
12.0B	47	"	1216	39.11	7.5	16	S. of 84	2
13.0A	52	"	1149	39.16	6.0	21	N. of 86	2
13.0B	53	"	1155	39.18	7.5	15	S. of 86	2
14.0A	58	"	1126	39.16	6.0	21	N. of 89	2
14.0B	59	"	1132	39.07	7.0	20	S. of 89	2
15.0A	64	"	1043	39.27	5.0	23	N. of 91	2
15.0B	65	"	1051	39.11	7.5	39	S. of 91	2
16.0A	70	"	1005	38.94	2.5	14	N. of 94	2
16.0B	71	"	1013	39.24	8.0	31	S. of 94	2
17.0A	76	"	0910	38.62	3.3	10	N. of 97	2
17.0B	77	"	0921	39.66	7.5	18	S. of 97	2
18.0A	82	"	0825	38.69	5.5	14	N. of 99	3
18.0B	83	"	0837	38.72	6.0	18	S. of 99	3

Table 13
Results of Analysis of Water Samples Collected at Sta 750

Field Location	Sampling		Depth	Salinity	Conc
	Date	Time	ft	ppt	mg/L
750+00	8/17/00	0749	46.0	39.11	231
750+00	"	0750	24.5	39.20	20
750+00	"	0752	3.0	39.19	18
750+00	"	0806	46.0	39.17	119
750+00	"	0809	24.5	39.11	46
750+00	"	0811	3.0	39.13	19
750+00	"	0900	46.5	39.19	70
750+00	"	0902	24.7	39.22	31
750+00	"	0904	3.0	39.19	27
750+00	"	1001	48.0	39.25	179
750+00	"	1003	25.5	39.15	53
750+00	"	1004	3.0	39.22	23
750+00	"	1113	51.0	39.15	730
750+00	"	1114	26.5	39.18	58
750+00	"	1115	3.0	39.13	38
750+00	"	1205	44.0	39.19	49
750+00	"	1206	23.5	39.17	37
750+00	"	1207	3.0	39.23	27
750+00	"	1303	49.5	39.33	82
750+00	"	1304	26.2	39.32	48
750+00	"	1305	3.0	39.28	28
750+00	"	1402	50.0	39.27	65
750+00	"	1403	26.5	39.26	41
750+00	"	1404	3.0	39.24	13
750+00	"	1503	50.0	39.30	46
750+00	"	1504	26.5	39.26	33
750+00	"	1505	3.0	39.23	14
750+00	"	1601	50.0	39.52	35
750+00	"	1602	26.5	39.21	21
750+00	"	1603	3.0	39.26	14
750+00	"	1701	50.0	39.31	31
750+00	"	1702	26.5	39.24	23
750+00	"	1703	3.0	39.20	16
750+00	"	1801	49.0	39.29	43
750+00	"	1802	25.5	39.24	21
750+00	"	1803	3.0	39.22	15
750+00	"	1901	49.0	39.25	38
750+00	"	1902	26.0	39.40	18
750+00	"	1903	3.0	39.21	16

Table 14
Annual Quantity of Dredging in Corpus Christi Navigation Channel

Reach	Zone	1978 CY/YR	1979 CY/YR	1980 CY/YR	1981 CY/YR	1982 CY/YR	1983 CY/YR	1984 CY/YR	1985 CY/YR	1986 CY/YR
1	1									
2	Harbor									
3	Channel									
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										

(Sheet 1 of 10)

Note: The quantities are in cu yd. Multiply by 0.76455 to convert them to cu m.

Table 14 (Continued)

Reach	Zone	1978 CY/YR	1979 CY/YR	1980 CY/YR	1981 CY/YR	1982 CY/YR	1983 CY/YR	1984 CY/YR	1985 CY/YR	1986 CY/YR
36	1 (cont)									
37										
38										
39										
40							166384			
41							180250			
42							277307			
43										
44							185396			
45							148317			
46							222475			
47							161676			
48							65838			
49							460867			
50										
51										
52	2					1311065			758787	
53	Open									
54	CC Bay									
55	Channel									
56										
57						831708			483200	
58										
59										
60										
61										
62						822984			492487	
63										
64										
65										
66										
67						689887			414331	
68										
69										
70										
71										
72						677915			406012	

Table 14 (Continued)										
		1978	1979	1980	1981	1982	1983	1984	1985	1986
Reach	Zone	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR
73	2 (cont)									
74										
75										
76										
77						650387			428688	
78										
79										
80										
81										
82						627802			395845	
83										
84										
85										
86										
87						583397			404807	
88										
89										
90										
91										
92						590020			441384	
93										
94										
95										
96										
97						580198			206889	
98	3									
99	Ingleside									
100	Channel									
101										
102						116040			41378	
103					285013					
104										
105										
106					82746					
107					101934					
108					407736					
109										

(Sheet 3 of 10)

Table 14 (Continued)										
		1978	1979	1980	1981	1982	1983	1984	1985	1986
Reach	Zone	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR
110	3 (cont)									
111										
112					66796					
113					138730					
114										
115										
116					51382					
117					307664					
118	4									
119	Redfish									
120	Bay									
121	Channel				76916					
122					416265					
123										
124										
125					693776					
126										
127										
128										
129										
130										
131										
132										
133										
134										
135	5									
136	Harbor									
137	Island									
138	Channel									
139										
140										
141										
142										
143										
144										
145										
146										

(Sheet 4 of 10)

Table 14 (Continued)

Reach	Zone	1978	1979	1980	1981	1982	1983	1984	1985	1986
		CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR
147	5 (cont)									
148										
149										
150										
151										
152										
153										
154										
155										
156	6									
157	Inner				335507					
158	Channel									
159										
160						88707				
161										
162										
163										
164										
165						94953				
166	7			337867		113944				
167	Outer	19648		225244		75963				77995
168	Channel	12280		140778		47477		46492		48747
169		36840		422333		142430		139477		146241
170		122801		1407778		773437		464923		487469
171										
172										
173										
174										
175		147362		1689334		411843		557908		584963
176										
177										
178										
179										
180										

(Sheet 5 of 10)

Table 14 (Continued)

Reach	Zone	1987 CY/YR	1988 CY/YR	1989 CY/YR	1990 CY/YR	1991 CY/YR	1992 CY/YR	1993 CY/YR	1994 CY/YR	1995 CY/YR
1	**1**									
2	Harbor									
3	Channel									
4										
5										
6										
7										
8										
9										
10										
11									302816	
12										
13										
14										
15										
16										
17									142677	
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34						199164				
35										
36										
37										

(Sheet 6 of 10)

Table 14 (Continued)

		1987	1988	1989	1990	1991	1992	1993	1994	1995
Reach	Zone	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR
38	1 (cont)					58300				
39										
40						46640				
41			134878			50526			147965	
42			207504			299126			227638	
43										
44			103752			201641			113819	
45			88303			161313			88662	
46			132454			195343			132993	
47			110378			162786			110827	
48			55189			52017			55414	
49			408729			364116			404532	
50										
51										
52	2	595237			327191			422511		511780
53	Open									
54	CC Bay									
55	Channel									
56										
57		371557			327191			274436		286785
58										
59										
60										
61										
62		327636			327191			201155		173855
63										
64										
65										
66										
67		248177			327191			179908		170583
68										
69										
70										
71										
72		227538			327191			198101		164597
73										
74										

(Sheet 7 of 10)

Table 14 (Continued)										
		1987	1988	1989	1990	1991	1992	1993	1994	1995
Reach	Zone	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR
75	2 (cont)									
76										
77		223650			327191			227398		165976
78										
79										
80										
81										
82		220739			327191			196364		154612
83										
84										
85										
86										
87		236411			327191			183578		165573
88										
89										
90										
91										
92		284960			327191			159218		180748
93										
94										
95										
96										
97		167948			327191			114676		142394
98	3									
99	Ingleside									
100	Channel									
101										
102		33590			65438			22935		43692
103		159689								135444
104										
105										
106										39322
107										
108						198500				
109										
110										
111										

(Sheet 8 of 10)

Table 14 (Continued)										
		1987	1988	1989	1990	1991	1992	1993	1994	1995
Reach	Zone	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR	CY/YR
112	3 (cont)					64512				
113										
114										
115										
116										
117										
118	4									
119	Redfish									
120	Bay									
121	Channel									
122										
123										
124										
125										
126										
127										
128										
129										
130										
131										
132										
133										
134										
135	5									
136	Harbor									
137	Island									
138	Channel									
139										
140										
141										
142										
143										
144										
145										
146										
147										

(Sheet 9 of 10)

Table 14 (Concluded)

Reach	Zone	1987 CY/YR	1988 CY/YR	1989 CY/YR	1990 CY/YR	1991 CY/YR	1992 CY/YR	1993 CY/YR	1994 CY/YR	1995 CY/YR
148	5 (cont)									
149										
150										
151										
152										
153										
154										
155										
156	6									
157	Inner									52567
158	Channel									73009
159										
160										131417
161										
162										
163										
164										
165										29204
166	7									35044
167	Outer									23363
168	Channel			10243						14602
169				30729			212978			43806
170				102429			709926			146018
171										
172										
173										
174										
175				122915			851912			175222
176										
177										
178										
179										
180										

(Sheet 10 of 10)

Table 15
Average Dredging Interval for Various Reaches of Corpus Christi Channel

Zone	Reach	Average Dredging Interval years
1	1	> 20
	2	> 20
	3	> 20
	4	> 20
	5	> 20
	6	> 20
	7	> 20
	8	> 20
	9	> 20
	10	> 20
	11	20
	12	20
	13	20
	14	20
	15	20
	16	20
	17	20
	18	20
	19	20
	20	20
	21	20
	22	> 20
	23	> 20
	24	> 20
	25	> 20
	26	> 20
	27	> 20
	28	> 20
	29	> 20
	30	> 20
	31	> 20
	32	> 20
	33	> 20
	34	20
	35	20

(Sheet 1 of 5)

Table 15 (Continued)		
Zone	Reach	Average Dredging Interval years
1 (cont)	36	20
	37	20
	38	20
	39	20
	40	10
	41	10
	42	5
	43	5
	44	5
	45	5
	46	5
	47	5
	48	5
	49	5
	50	5
	51	5
2	52	3.3
	53	3.3
	54	3.3
	55	3.3
	56	3.3
	57	3.3
	58	3.3
	59	3.3
	60	3.3
	61	3.3
	62	3.3
	63	3.3
	64	3.3
	65	3.3
	66	3.3
	67	3.3
	68	3.3
	69	3.3
	70	3.3
	71	3.3
	72	3.3
		(Sheet 2 of 5)

Table 15 (Continued)		
Zone	Reach	Average Dredging Interval years
2 (cont)	73	3.3
	74	3.3
	75	3.3
	76	3.3
	77	3.3
	78	3.3
	79	3.3
	80	3.3
	81	3.3
	82	3.3
	83	3.3
	84	3.3
	85	3.3
	86	3.3
	87	3.3
	88	3.3
	89	3.3
	90	3.3
	91	3.3
	92	3.3
	93	3.3
	94	3.3
	95	3.3
	96	3.3
	97	3.3
3	98	3.3
	99	3.3
	100	3.3
	101	3.3
	102	3.3
	103	6.7
	104	6.7
	105	6.7
	106	10
	107	20
	108	10
	109	10
		(Sheet 3 of 5)

Table 15 (Continued)		
Zone	**Reach**	**Average Dredging Interval years**
3 (cont)	110	10
	111	10
	112	10
	113	20
	114	20
	115	20
	116	20
	117	20
4	118	20
	119	20
	120	20
	121	20
	122	20
	123	20
	124	20
	125	20
	126	20
	127	20
	128	20
	129	20
	130	> 20
	131	> 20
	132	> 20
	133	> 20
	134	> 20
5	135	> 20
	136	> 20
	137	> 20
	138	> 20
	139	> 20
	140	> 20
	141	> 20
	142	> 20
	143	> 20
	144	> 20
	145	> 20
	146	> 20
		(Sheet 4 of 5)

Table 15 (Concluded)

Zone	Reach	Average Dredging Interval years
5 (cont)	147	> 20
	148	> 20
	149	> 20
	150	> 20
	151	> 20
	152	> 20
	153	> 20
	154	> 20
	155	> 20
6	156	> 20
	157	10
	158	20
	159	20
	160	10
	161	10
	162	10
	163	10
	164	10
	165	10
7	166	6.7
	167	4
	168	2.9
	169	2.5
	170	2.5
	171	2.5
	172	2.5
	173	2.5
	174	2.5
	175	2.5
	176	2.5
	177	2.5
	178	2.5
	179	2.5
	180	2.5

(Sheet 5 of 5)

Table 16
Estimated Dredging Quantities in Corpus Christi Navigation Channel

Zone	Sediment Description	Total Quantity Dredged cu yd	Percentage	Average Per Year cu yd	Estimated Dredging Per Year (cu yd) with 52' x 500' Channel
1	90 % silt+clay	6,628,012	14.93	331,401	400,000
2	90 to 99 % silt+clay	22,247,804	50.12	1,112,390	1,700,000
3	90 % sand	2,362,541	5.32	118,127	150,000
4	70 % sand 30 % silt+clay	1,186,957	2.67	59,348	100,000
5	95 % sand	0	0	0	0
6	95 % sand (assumed)	681,207	1.53	34,060	50,000
7	95 % sand (assumed)	11,284,918	25.42	564,246	700,000
Totals		44,391,439	100	2,219,572	3,100,000

Note: Multiply by 0.76455 to convert cu yd to cu m.

Table 17
Conditions Used for Running Numerical Model

No.	Bathymetry	Tide	Wind
1	Base	June Tide	No wind
2	Base	June Tide	SE wind
3	Base	October Tide	No wind
4	Base	October Tide	North wind
5	Plan	June Tide	No wind
6	Plan	October Tide	No wind

Table 18
Locations of Velocity Gages along Corpus Christi Navigation Channel

Section	Gage	Place	Distance from Center, ft	Depth, ft
1	1	N	273	30.2
	44	C	0	88.4
	87	S	230	25.8
2	2	N	305	37.0
	45	C	0	46.0
	88	S	426	46.0
3	3	N	397	15.2
	46	C	0	46.0
	89	S	283	28.9
4	4	N	383	21.2
	47	C	0	46.0
	90	S	265	46
5	5	N	422	20.6
	48	C	0	46.0
	91	S	277	32.0
6	6	N	299	43.2
	49	C	0	46.0
	92	S	318	46
7	7	N	276	42.5
	50	C	0	46.0
	93	S	432	46
8	8	N	260	34.2
	51	C	0	46.0
	94	S	317	46
9	9	N	353	31.4
	52	C	0	46.0
	95	S	365	46.0
10	10	N	948	11.1
	53	C	0	50.4
	96	S	837	6.4
11	11	N	124	13.8
	54	C	0	41.5
	97	S	970	11.2
12	12	N	1036	15.3
	55	C	0	51.2
	98	S	1146	10.9
13	13	N	1196	14.2
	56	C	0	49.8
	99	S	1179	11.4

(Sheet 1 of 4)

Note: Multiply by 0.3048 to convert feet to meters.

Table 18 (Continued)

Section	Gage	Place	Distance from Center, ft	Depth, ft
14	14	N	1158	12.7
	57	C	0	49.6
	100	S	1200	14.3
15	15	N	1039	13.4
	58	C	0	53.4
	101	S	1140	15.1
16	16	N	940	14.2
	59	C	0	50.0
	102	S	890	15.1
17	17	N	1022	13.6
	60	C	0	46.9
	103	S	992	14.8
18	18	N	1005	12.7
	61	C	0	51.5
	104	S	880	4.53
19	19	N	967	44.0
	62	C	0	52.3
	105	S	902	4.0
20	20	N	1070	44.7
	63	C	0	53.0
	106	S	797	5.4
21	21	N	821	28.6
	64	C	0	48.6
	107	S	760	11.6
22	22	N	1167	27.8
	65	C	0	52.5
	108	S	1231	3.3
23	23	N	998	5.0
	66	C	0	53.2
	109	S	821	3.8
24	24	N	1244	8.1
	67	C	0	51.1
	110	S	874	4.7
25	25	N	1374	9.7
	68	C	0	50.7
	111	S	1092	6.7
26	26	N	1329	9.5
	69	C	0	51.3
	112	S	1148	4.2
27	27	N	1417	7.5
	70	C	0	48.8
	113	S	828	8.9

(Sheet 2 of 4)

Table 18 (Continued)

Section	Gage	Place	Distance from Center, ft	Depth, ft
28	28	N	1369	6.8
	71	C	0	48.8
	114	S	811	8.4
29	29	N	1283	7.4
	72	C	0	50.2
	115	S	826	9.49
30	30	N	1346	8.13
	73	C	0	53.2
	116	S	847	8.05
31	31	N	1289	9.74
	74	C	0	55.1
	117	S	963	6.14
32	32	N	1425	3.43
	75	C	0	54.9
	118	S	749	9.00
33	33	N	1134	3.58
	76	C	0	53.4
	119	S	686	8.29
34	34	N	1033	3.36
	77	C	0	52.2
	120	S	662	11.1
35	35	N	921	4.14
	78	C	0	54.1
	121	S	772	8.38
36	36	N	1050	16.2
	79	C	0	51.0
	122	S	667	7.30
37	37	N	842	30.5
	80	C	0	52.7
	123	S	673	10.9
38	38	N	760	20.2
	81	C	0	60.1
	124	S	711	20.6
39	39	N	482	34.0
	82	C	0	51.0
	125	S	515	37.1
40	40	N	613	30.7
	83	C	0	49.1
	126	S	540	36.0
41	41	N	1461	30.0
	84	C	0	49.7
	127	S	1014	30.0

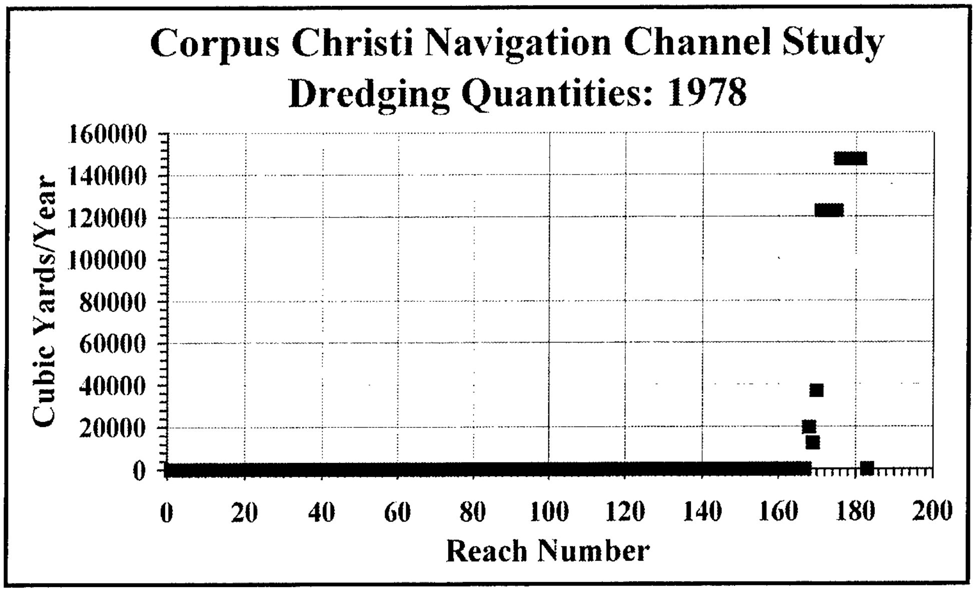
(Sheet 3 of 4)

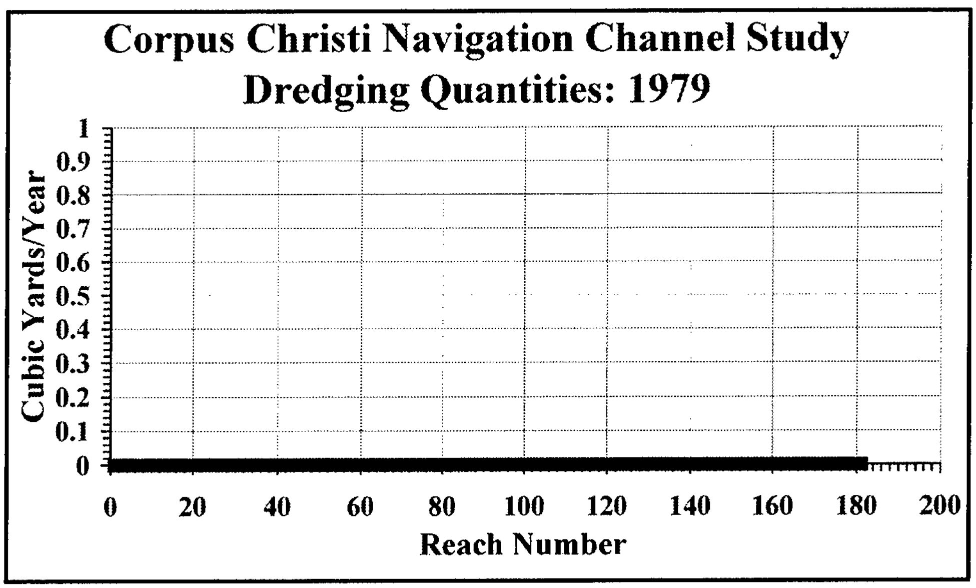
Table 18 (Concluded)				
Section	Gage	Place	Distance from Center, ft	Depth, ft
42	42	N	1542	35.2
	85	C	0	50.3
	128	S	1526	38.3
43	43	N	1928	41.0
	86	C	0	49.3
	129	S	1920	41.7
				(Sheet 4 of 4)

Table 19
Reach Locations and Gage Numbers

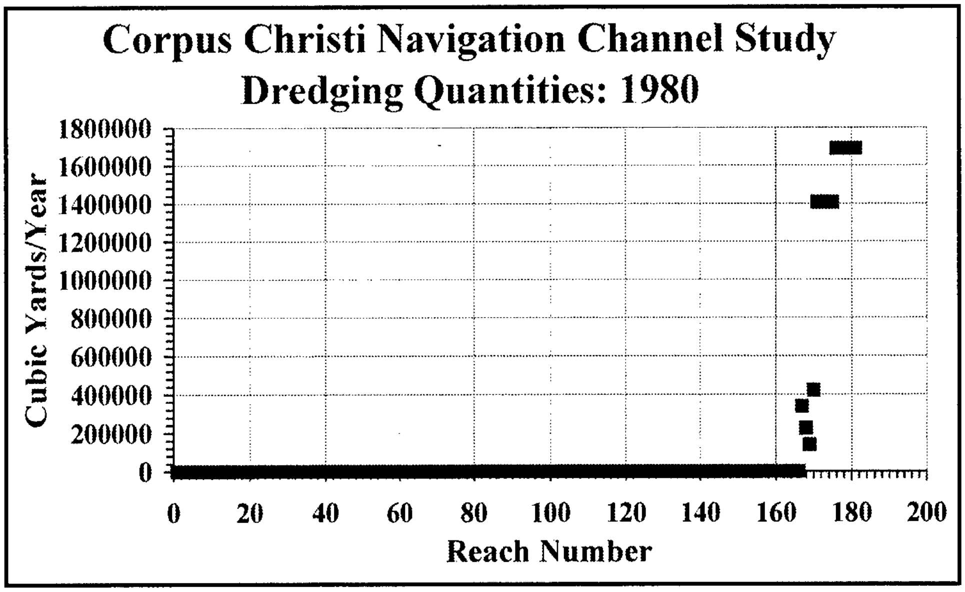
Section	Reach Location	Zone	Gage Numbers
1	27	1	5 48 91
2	58	2	12 55 98
3	75	2	14 57 100
4	92	2	16 59 102
5	107	3	20 63 106
6	120	4	26 69 112
7	125	4	28 71 114
8	142	5	34 77 120
9	161	6	39 82 125
10	174	7	42 85 128

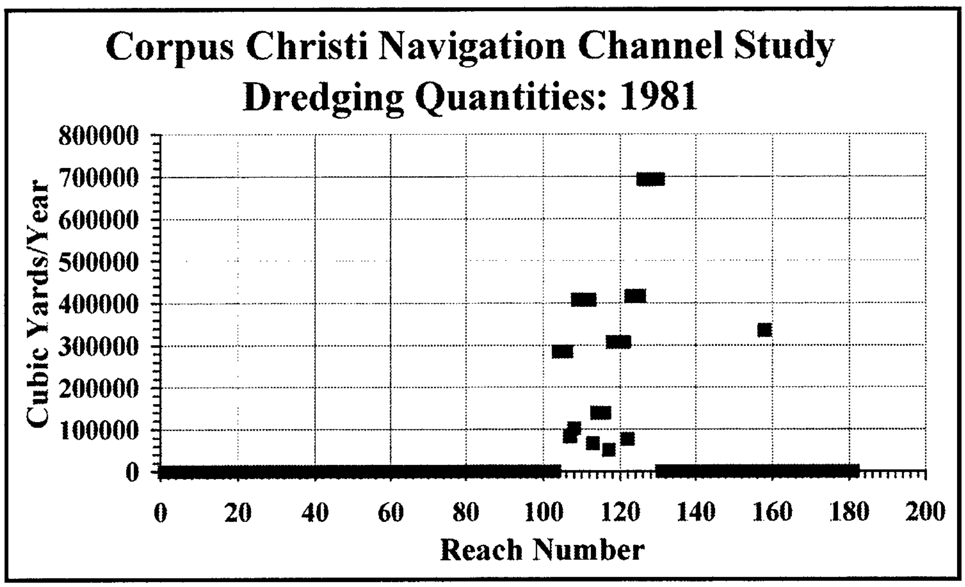
Appendix A
Plots of Annual Dredging in the Corpus Christi Navigation Channel

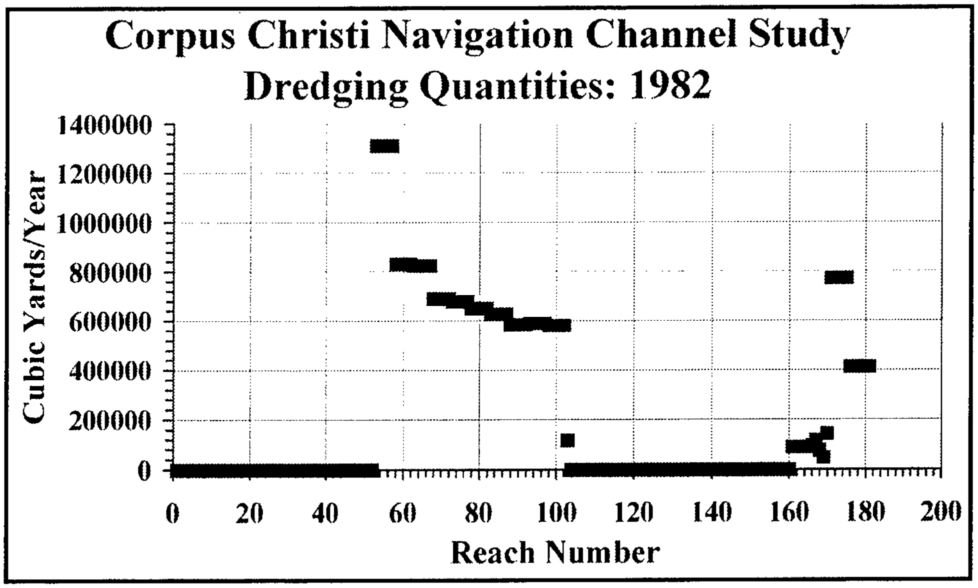


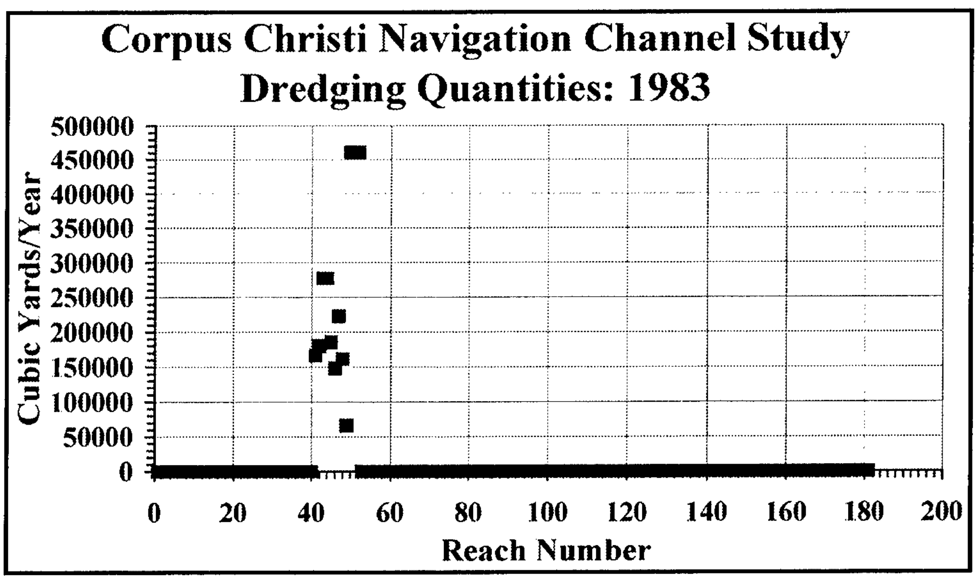


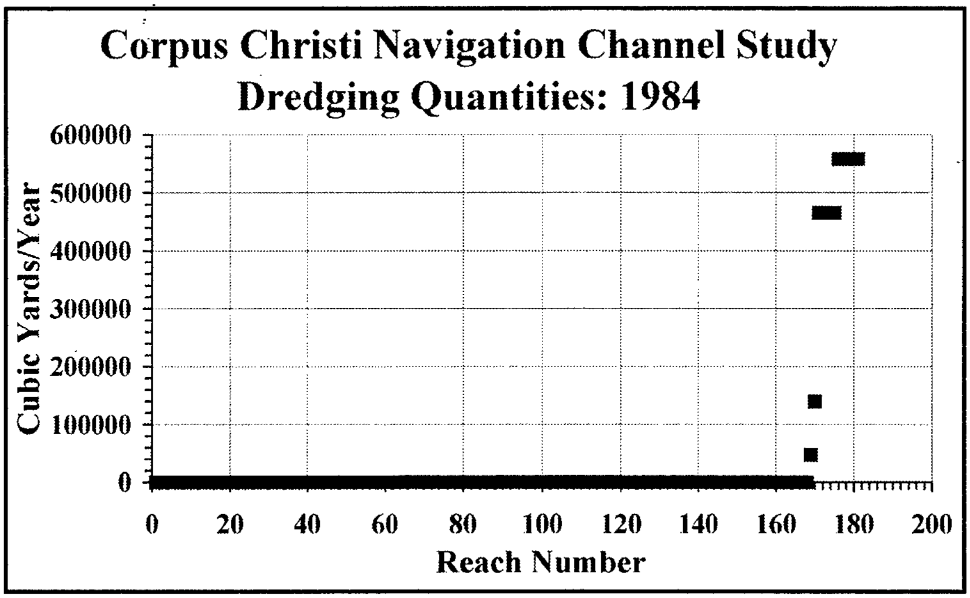
(To convert cubic yards to cubic meters, multiply by 0.7645549)

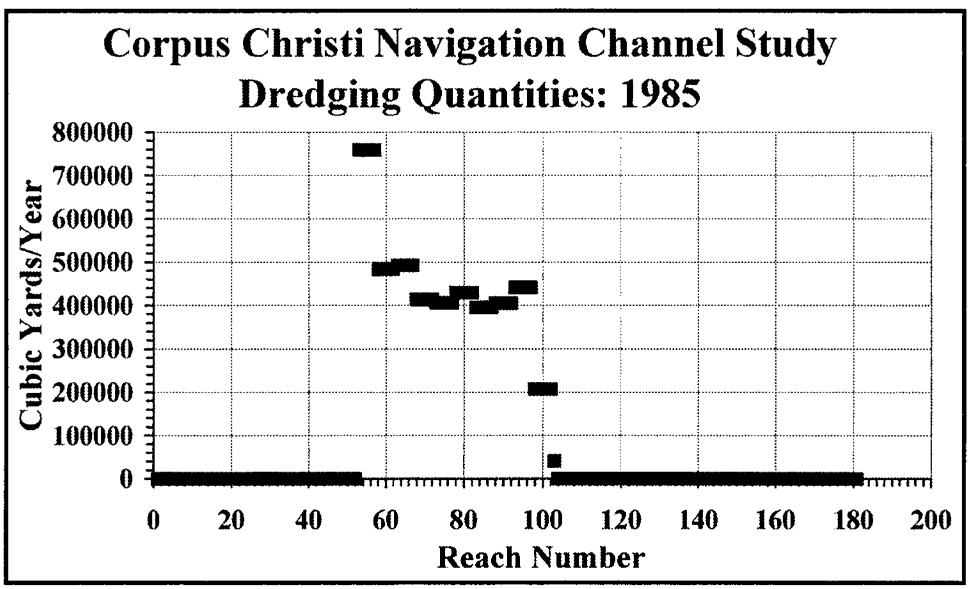

Corpus Christi Navigation Channel Study
Dredging Quantities: 1980
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
Cubic Yards/Year
0
20
40
60
80
100
120
140
160
180
200
Reach Number

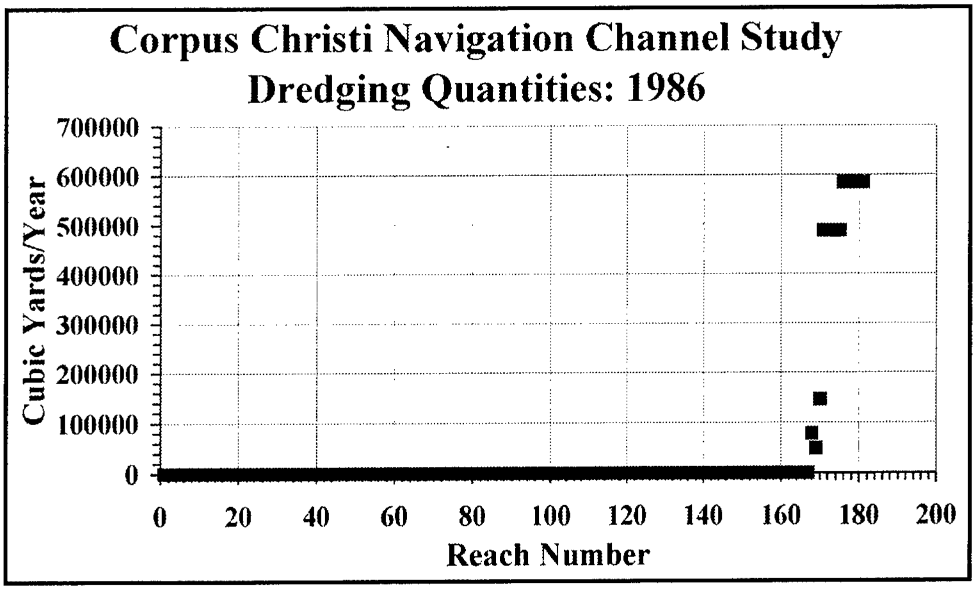

Corpus Christi Navigation Channel Study
Dredging Quantities: 1981
800000
700000
600000
500000
400000
300000
200000
100000
0
Cubic Yards/Year
0
20
40
60
80
100
120
140
160
180
200
Reach Number


Corpus Christi Navigation Channel Study
Dredging Quantities: 1982
Cubic Yards/Year
1400000
1200000
1000000
800000
600000
400000
200000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number

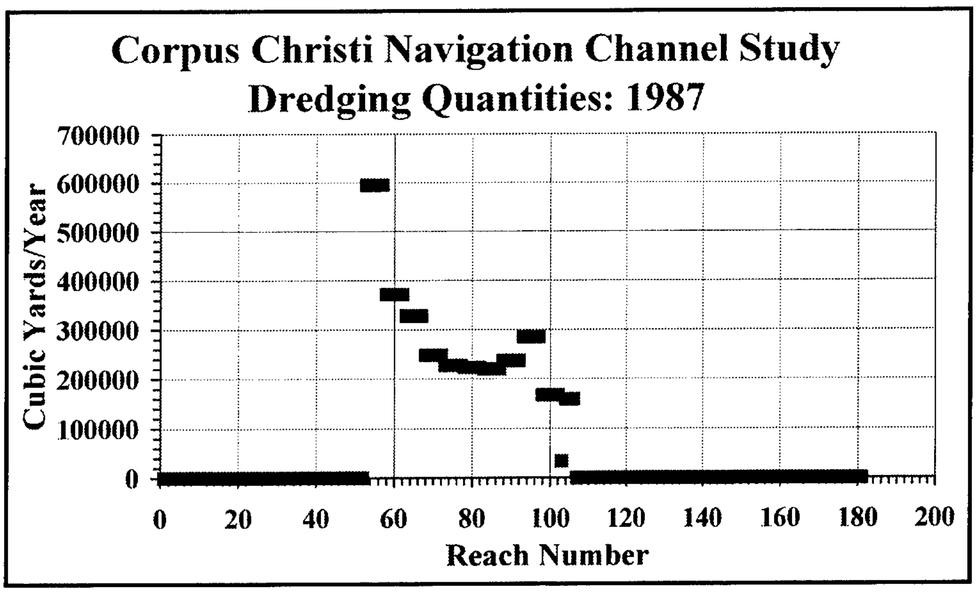

Corpus Christi Navigation Channel Study
Dredging Quantities: 1983
Cubic Yards/Year
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number


Corpus Christi Navigation Channel Study
Dredging Quantities: 1984
Cubic Yards/Year
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number

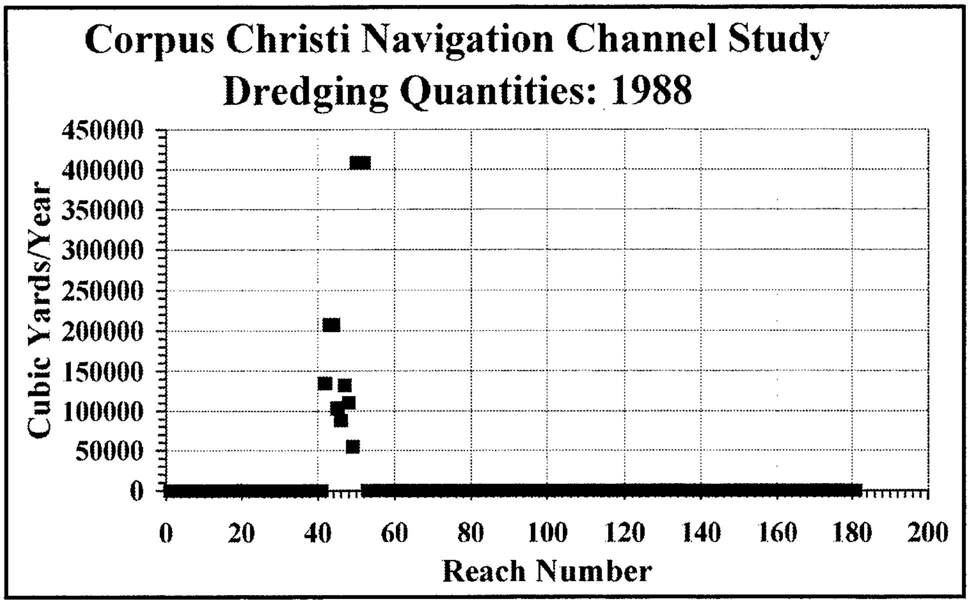

Corpus Christi Navigation Channel Study
Dredging Quantities: 1985
Cubic Yards/Year
800000
700000
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number



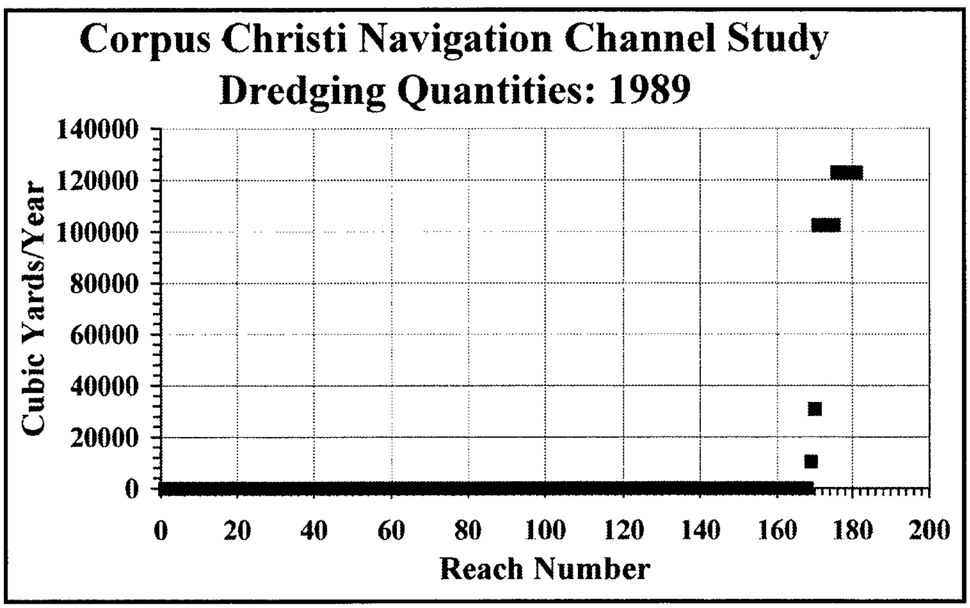
Corpus Christi Navigation Channel Study
Dredging Quantities: 1986
Cubic Yards/Year
700000
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number



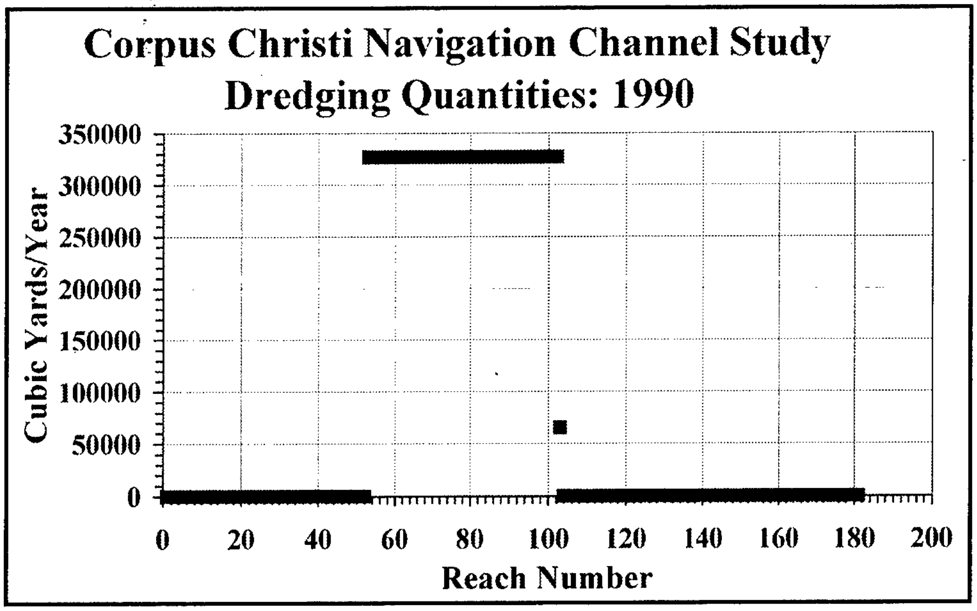
Corpus Christi Navigation Channel Study
Dredging Quantities: 1987
Cubic Yards/Year
700000
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number

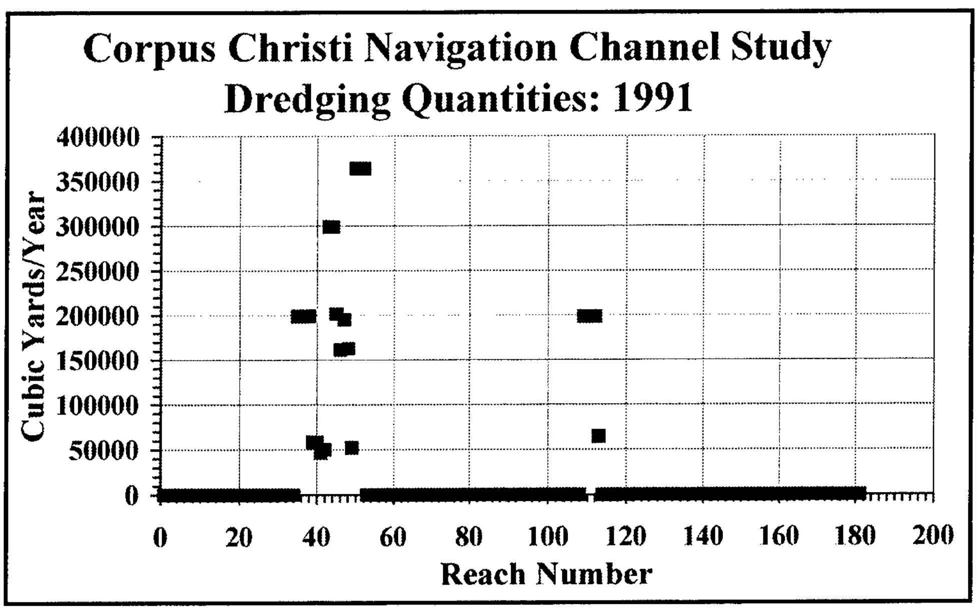


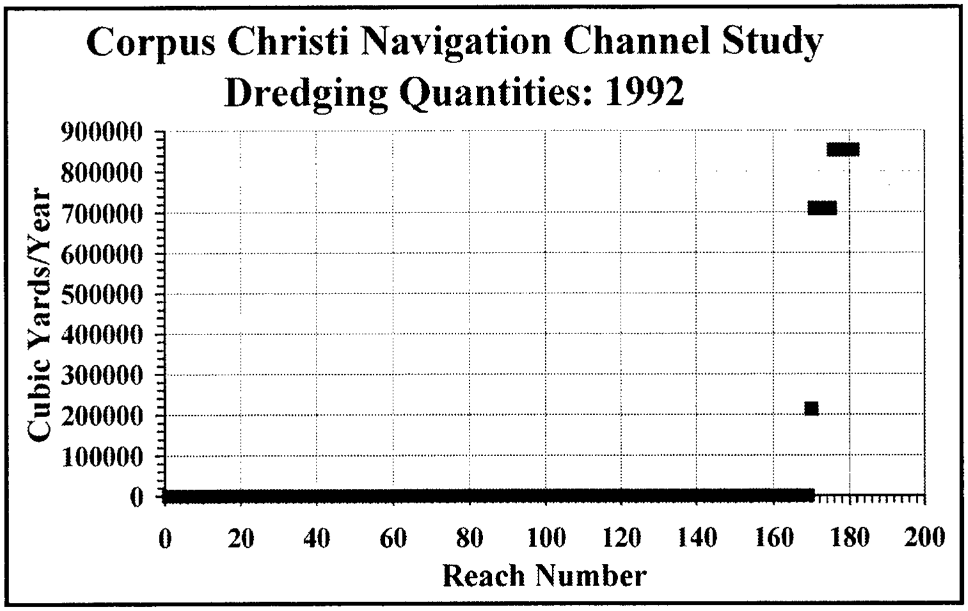
Corpus Christi Navigation Channel Study
Dredging Quantities: 1988
Cubic Yards/Year
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number

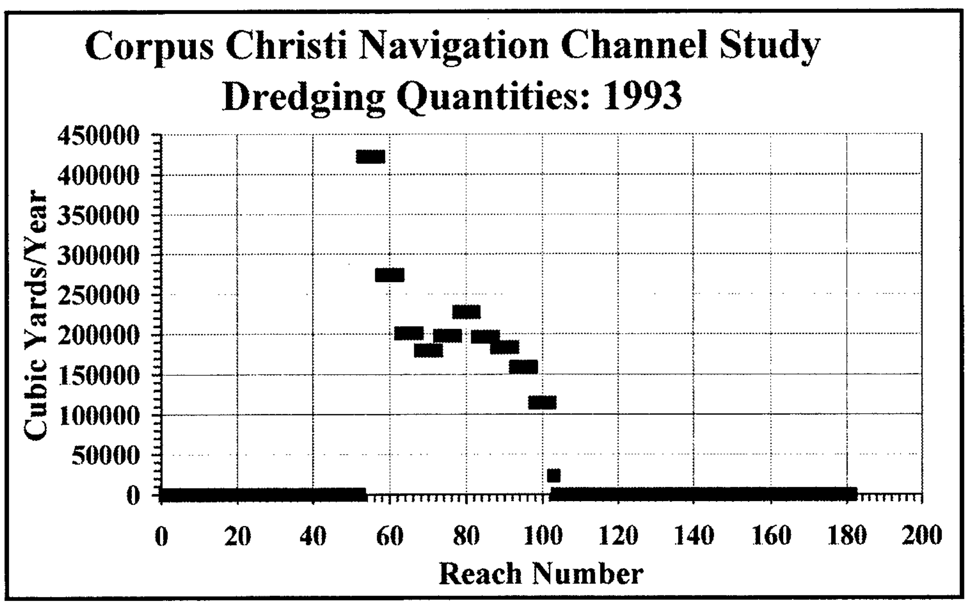


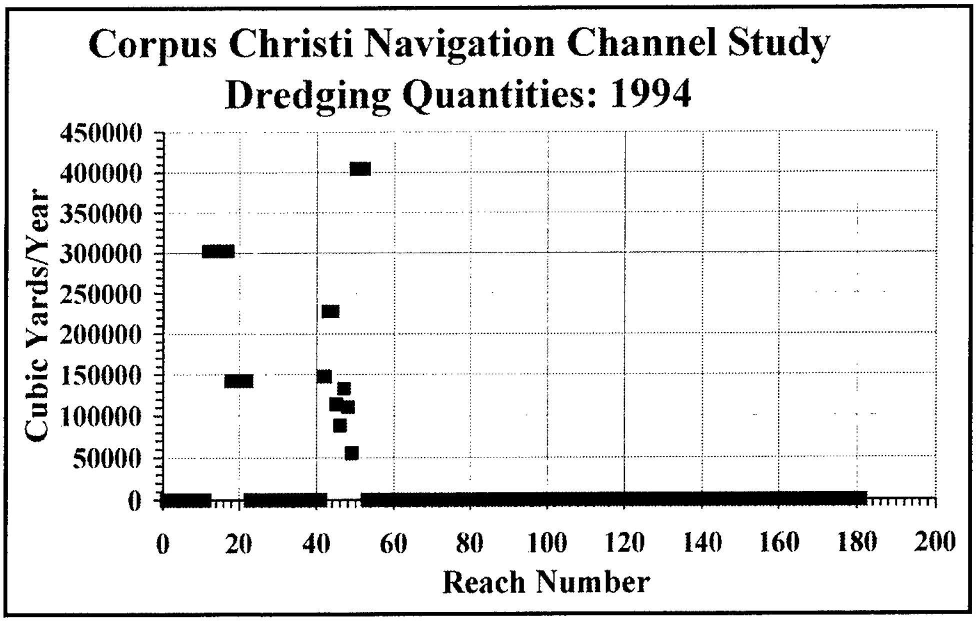
Corpus Christi Navigation Channel Study
Dredging Quantities: 1989
Cubic Yards/Year
140000
120000
100000
80000
60000
40000
20000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number

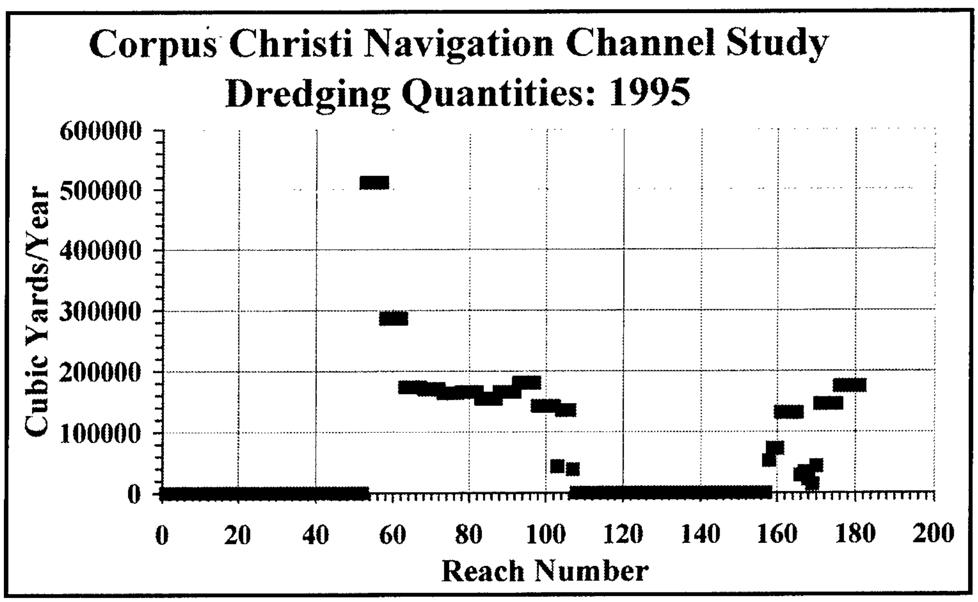

Corpus Christi Navigation Channel Study
Dredging Quantities: 1990
Cubic Yards/Year
350000
300000
250000
200000
150000
100000
50000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number


Corpus Christi Navigation Channel Study
Dredging Quantities: 1991
Cubic Yards/Year
400000
350000
300000
250000
200000
150000
100000
50000
0
0
20
40
60
80
100
120
140
160
180
200
Reach Number


Corpus Christi Navigation Channel Study
Dredging Quantities: 1992
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
Cubic Yards/Year
0
20
40
60
80
100
120
140
160
180
200
Reach Number


Corpus Christi Navigation Channel Study
Dredging Quantities: 1993
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Cubic Yards/Year
0
20
40
60
80
100
120
140
160
180
200
Reach Number


Corpus Christi Navigation Channel Study
Dredging Quantities: 1994
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Cubic Yards/Year
0
20
40
60
80
100
120
140
160
180
200
Reach Number


Corpus Christi Navigation Channel Study
Dredging Quantities: 1995
600000
500000
400000
300000
200000
100000
0
Cubic Yards/Year
0
20
40
60
80
100
120
140
160
180
200
Reach Number

Appendix B
Analysis of Cross Sections of Corpus Christi Navigation Channel

Table B1
Analysis of Cross Sections of Corpus Christi Navigation Channel

Sheet	Date	Section Number of Cross Section	Location of Cross Section	Bed Level: Bottom Left	Bed Level: Bottom Center	Bed Level: Bottom Right
1	19-Sep-96	1	220	52.5	53	44
	Redfish	2	225	49	52	46
	Bay Channel	3	230	50	52	45
		4	235	47	53	48
		5	240	48	51	45
		6	245	45	52	49
		7	250	46	51	46
		8	255	43	51	49
		9	260	47	54	46
		10	265	44	54	48
2	6-Jan-90	1	260	46	54	47
	Redfish	2	270	48	52	47
	Bay Chan.	3	280	48	51	48
		4	290	47	50	45
		5	300	44	50	42
		6	310	40	51	44
		7	320	41	50	44
		8	330	39	50	46
		9	340	41	50	44
		10	350	41	50	47
		11	360	40	51	49
		12	370	43	53	49
		13	380	42	57	48

(Sheet 1 of 6)

Table B1 (Continued)						
				Bed Level		
Sheet	Date	Section Number of Cross Section	Location of Cross Section	Bottom Left	Bottom Center	Bottom Right
3	6-Jun-96	1	400	47	51	47
	Ingleside	2	410	42	52	49
	Chan.	3	420	43	52	47
		4	430	43	52	47
		5	437	43	52	47
		6	440	40	51	42
		7	450	40	51	41
		8	460	46	50	45
		9	470	45	49	47
		10	479	37	50	43
		11	490	46	52	47
		12	500	47	52	47
		13	510	47	52	53
		14	520	47	52	49
4	6-Jun-96	1	530	47	50	47
	Ingleside	2	540	47	50	48
	Chan.					
5	10-Sep-96	1	170	49	49	49
	Outer Chan.	2	175	49	49	49
		3	180	49	49	49
		4	185	49	49	49
		5	190	49	49	49
		6	195	49	49	49
		7	200	49	49	49
		8	205	49	49	49
		9	210	49	49	49
6	10-Sep-96	1	125	49	49	49
	Outer Chan.	2	130	49	49	49
		3	135	49	49	49
		4	140	49	49	49
		5	145	49	49	49
		6	150	49	49	49
		7	155	49	49	49
		8	160	49	49	49
		9	165	49	49	49
7	10-Sep-96	1	80	51	55	47
	Outer Chan.	2	85	51	52	48
		3	90	49	50	47
		5	100	49	50	46
		6	105	48	50	46
		7	110	48	50	45
		8	115	48	50	46
		9	120	48	50	47
						(Sheet 2 of 6)

Table B1 (Continued)						
				Bed Level		
Sheet	**Date**	**Section Number of Cross Section**	**Location of Cross Section**	**Bottom Left**	**Bottom Center**	**Bottom Right**
7 (cont)	10-Sep-96					
	Outer Chan.					
8	10-Sep-96	1	75	51	60	49
	Outer					
	Chan.					
9	11-Sep-96	1	10	55	58	60
	Inner Chan	2	15	60	60	56
		3	20	58	53	52
		4	25	58	53	50
		5	30	63	56	48
		6	35	62	50	45
		7	40	60	60	47
		8	45	62	62	55
		9	50	66	55	66
		10	55	65	64	64
		11	60	55	63	57
		12	65	59	61	60
		13	70	52	61	50
		14	72.5	49	59	50
10	11-Sep-96	1	-38.08	58	47	43
	Outer Chan.	2	-33.57	44	52	26
		3	-21.36	55	59	52
		4	-5	55	56	53
		5	0	52	57	50
		6	5	57	57	58
11	19-Sep-96	1	12.55	45	56	57
	Horbor	2	15	43	55	65
	Island	3	20	46	52	59
	Chan.	4	25	47	53	55
		5	30	46	49	49
		6	35	38	47	46
		7	40	39	48	49
		8	45	39	49	49
		9	50	41	49	48
		10	55	39	49	50
		11	60	42	50	49
		12	65	34	50	48
		13	70	47	50	48
		14	75	47	49	50
						(Sheet 3 of 6)

Table B1 (Continued)						
				Bed Level		
Sheet	Date	Section Number of Cross Section	Location of Cross Section	Bottom Left	Bottom Center	Bottom Right
12	19-Sep-96 Horbor Island Chan.	1	80	46	47	49
		2	85	47	49	47
		3	90	47	49	48
		4	95	47	50	47
		5	100	49	50	45
		6	105	48	52	49
		7	110	49	52	47
		8	115	49	52	49
		9	120	50	51	46
		10	125	47	52	47
		11	130	47	51	45
		12	135	47	51	50
		13	140	49	51	49
		14	145	46	50	49
13	19-Sep-96 Horbor Island Chan.	1	150	47	51	49
		2	155	47	53	42
		3	160	52	54	46
		4	165	46	53	50
		5	170	49	53	49
		6	175	49	51	49
		7	180	49	50	48
		8	185	46	50	50
		9	190	47	52	47
		10	195	46	51	47
		11	200	47	53	46
		12	205	49	53	47
		13	210	49	54	43
		14	215	49	52	49
14	19-Aug-96 Horbor Chan.	1	1111.9	47	49	49
		2	1115	48	51	49
		3	1120	51	53	50
		4	1125	49	52	51
		5	1130	51	53	51
		6	1135	52	51	50
		7	1140	51	51	49
		8	1145	47	52	47
		9	1150	47	49	47
		10	1155	46	49	47
		11	1160	47	49	47
		12	1162.6	46	50	47
17	27-Jan-95 Outer Chan.	1	194	48	48	48
		2	196	49	49	49
		3	198	49	49	49

(Sheet 4 of 6)

Table B1 (Continued)						
		Section Number of Cross Section	Location of Cross Section	Bed Level		
Sheet	Date			Bottom Left	Bottom Center	Bottom Right
17 (cont)	27-Jan-95	4	200	49	49	49
	Outer Chan.	5	202	49	49	49
		6	204	49	49	49
		7	206	49	49	49
		8	208	49	49	49
		9	210	49	49	49
18	27-Jan-95	1	176	48	48	46
	Outer Chan.	2	178	48	48	48
		3	180	48	48	48
		4	182	48	48	48
		5	184	48	48	48
		6	186	48	48	48
		7	188	48	48	48
		8	190	48	48	48
		9	192	48	48	48
19	27-Jan-95	1	160	48	48	48
	Outer Chan.	2	162	48	48	48
		3	164	48	48	48
		4	166	48	48	48
		5	168	48	48	48
		6	170	48	48	48
		7	172	48	48	48
		8	174	48	48	48
20		1	144	50	50	50
	Outer Chan.	2	146	50	50	50
		3	148	50	50	50
		4	150	50	50	50
		5	152	50	50	50
		6	154	50	50	50
		7	156	50	50	50
		8	158	50	50	50
		9	160	50	50	50
21		1	126	50	50	50
	Outer Chan.	2	128	50	50	50
		3	130	50	50	50
		4	132	50	50	50
		5	134	50	50	50
		6	136	50	50	50
		7	138	50	50	50
		8	140	50	50	50
		9	142	50	50	50

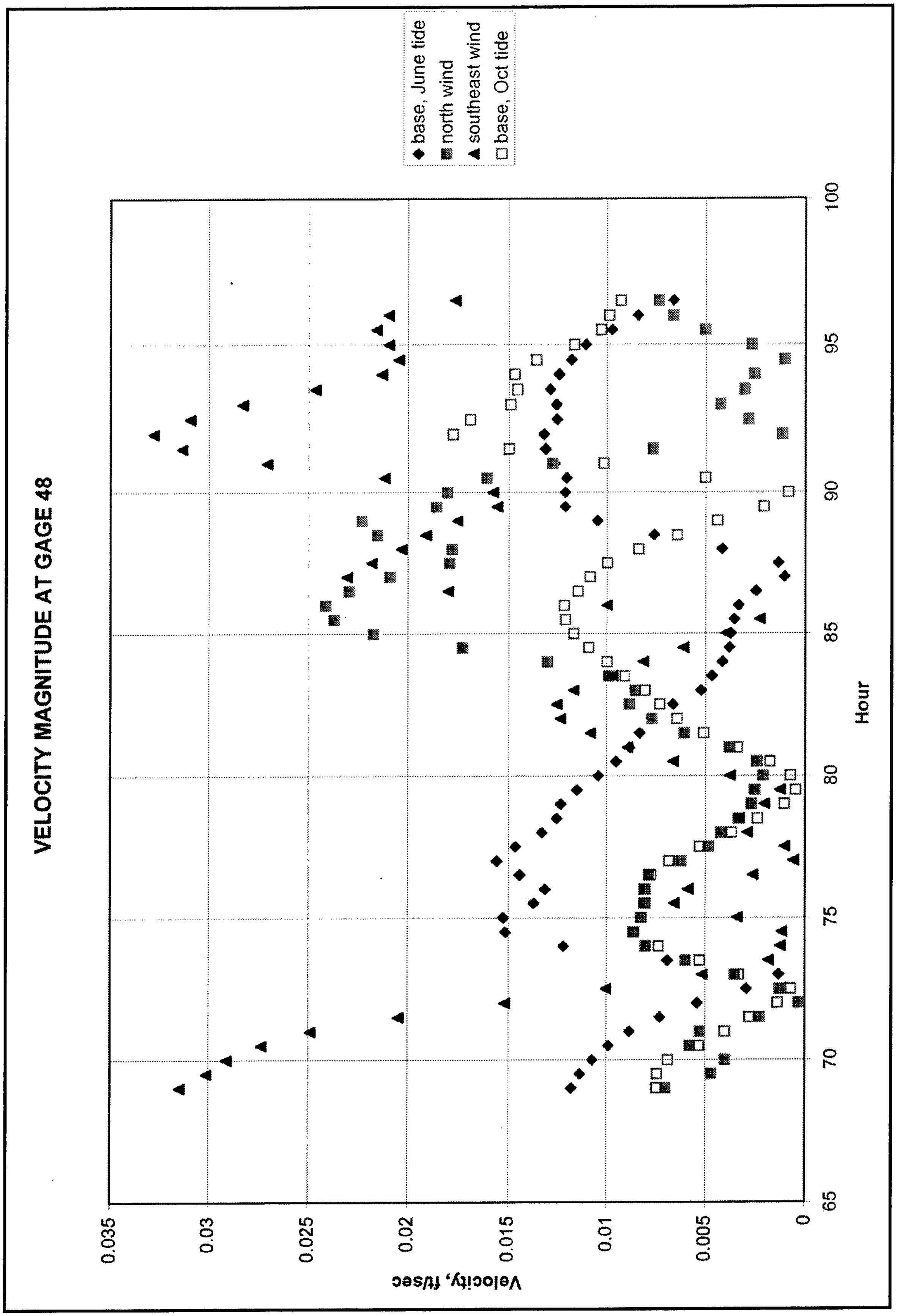
(Sheet 5 of 6)

Table B1 (Concluded)

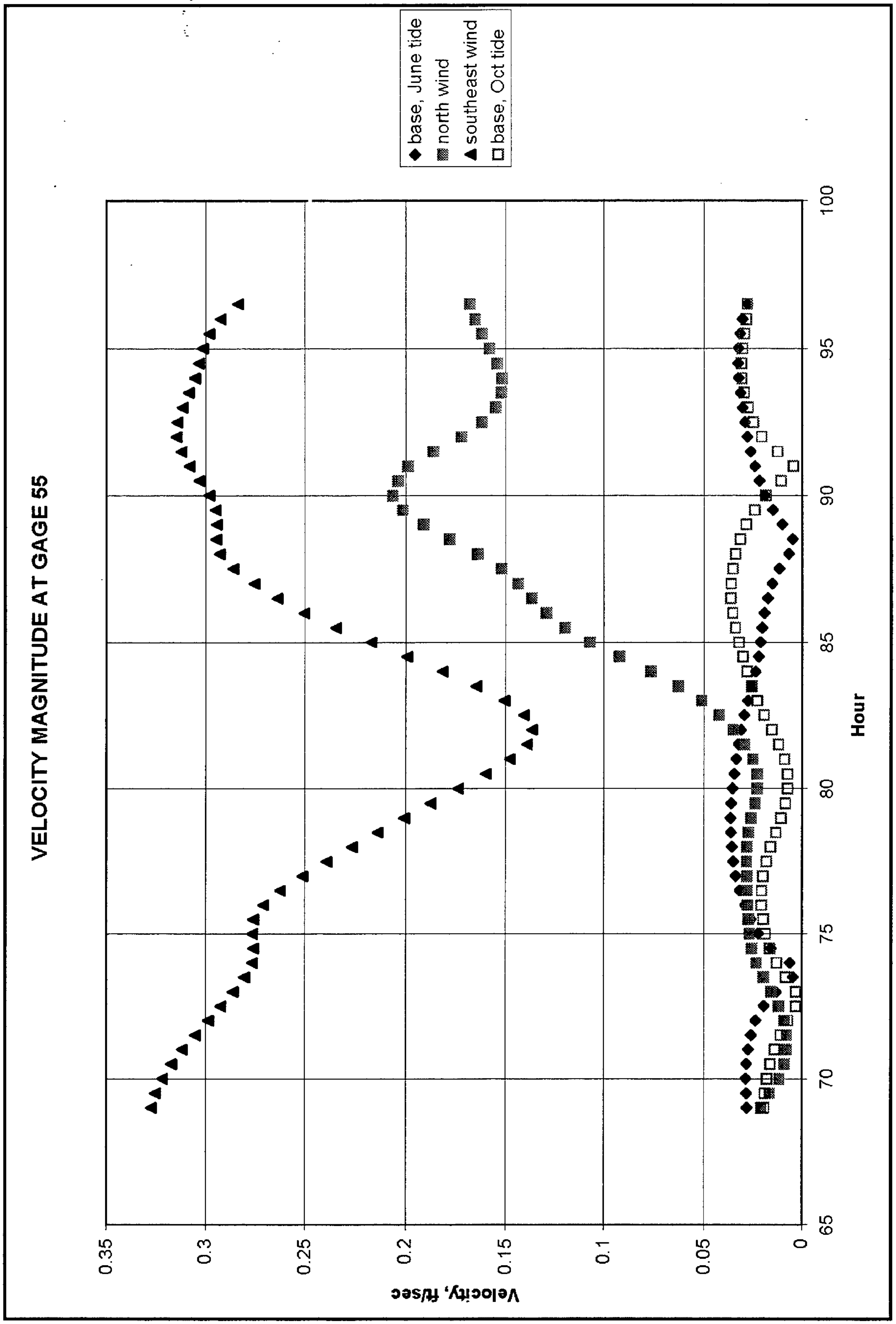
Sheet	Date	Section Number of Cross Section	Location of Cross Section	Bed Level		
				Bottom Left	Bottom Center	Bottom Right
22		1	120	50	50	50
	Outer Chan.	2	122	50	50	50
		3	124	50	50	50
25	Aug-92	1	120	45	50	45
	Outer Chan.	2	130	46	49	45
		3	140	47	49	46
		4	150	48	50	47
		5	160	48	50	47
		6	170	47	49	47
		7	180	48	49	48
		8	190	48	49	48
		9	200	48	50	48
		10	210	49	49	49
26	Aug-92	1	35	60	52	52
	Outer Chan.	2	40	64	61	45
		3	45	65	56	46
		4	50	64	65	45
		5	55	66	65	60
		6	85	51	55	49
		7	90	48	50	45
		8	100	45	48	43
		9	110	45	49	43
		10	115	45	52	44

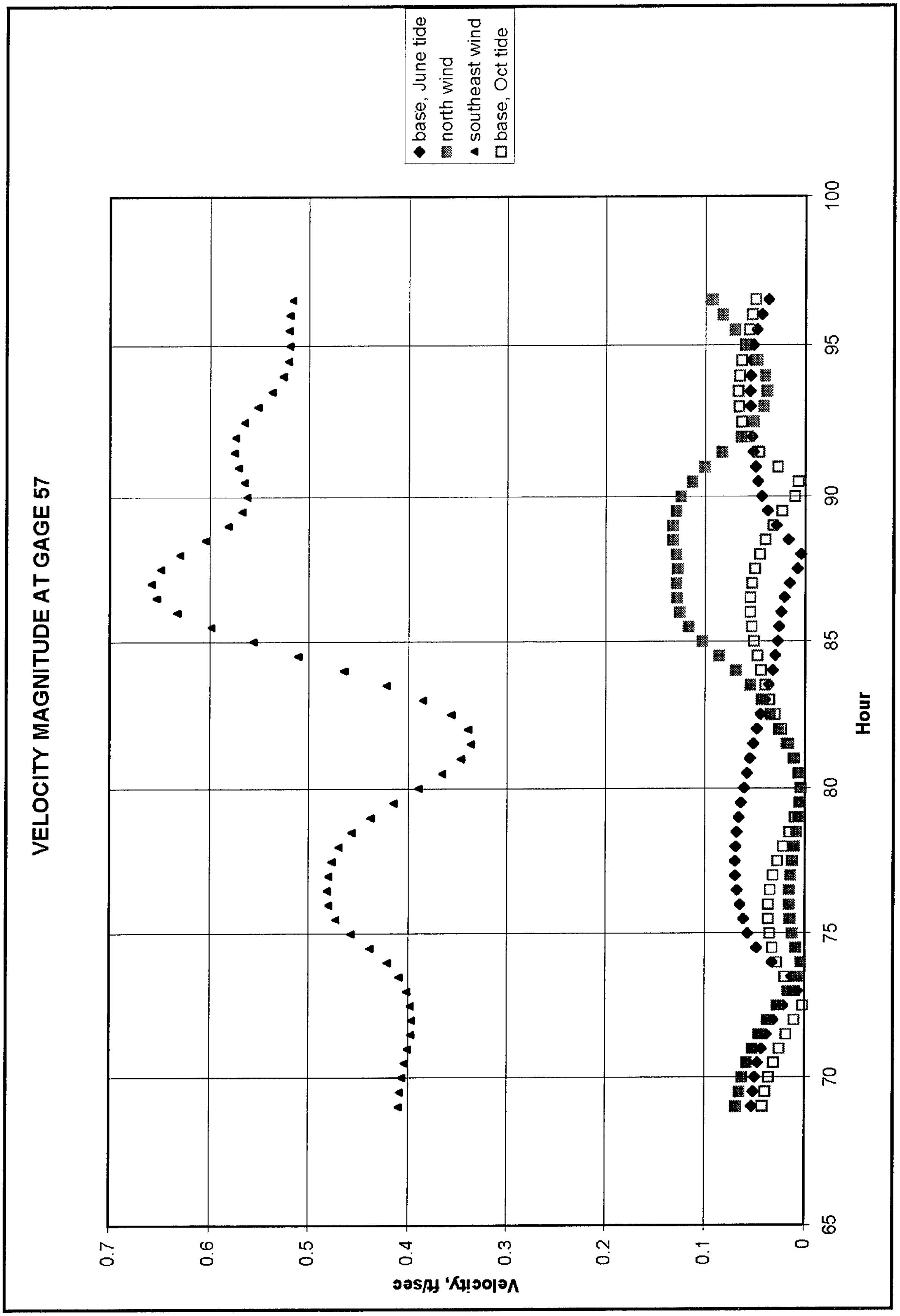
(Sheet 6 of 6)

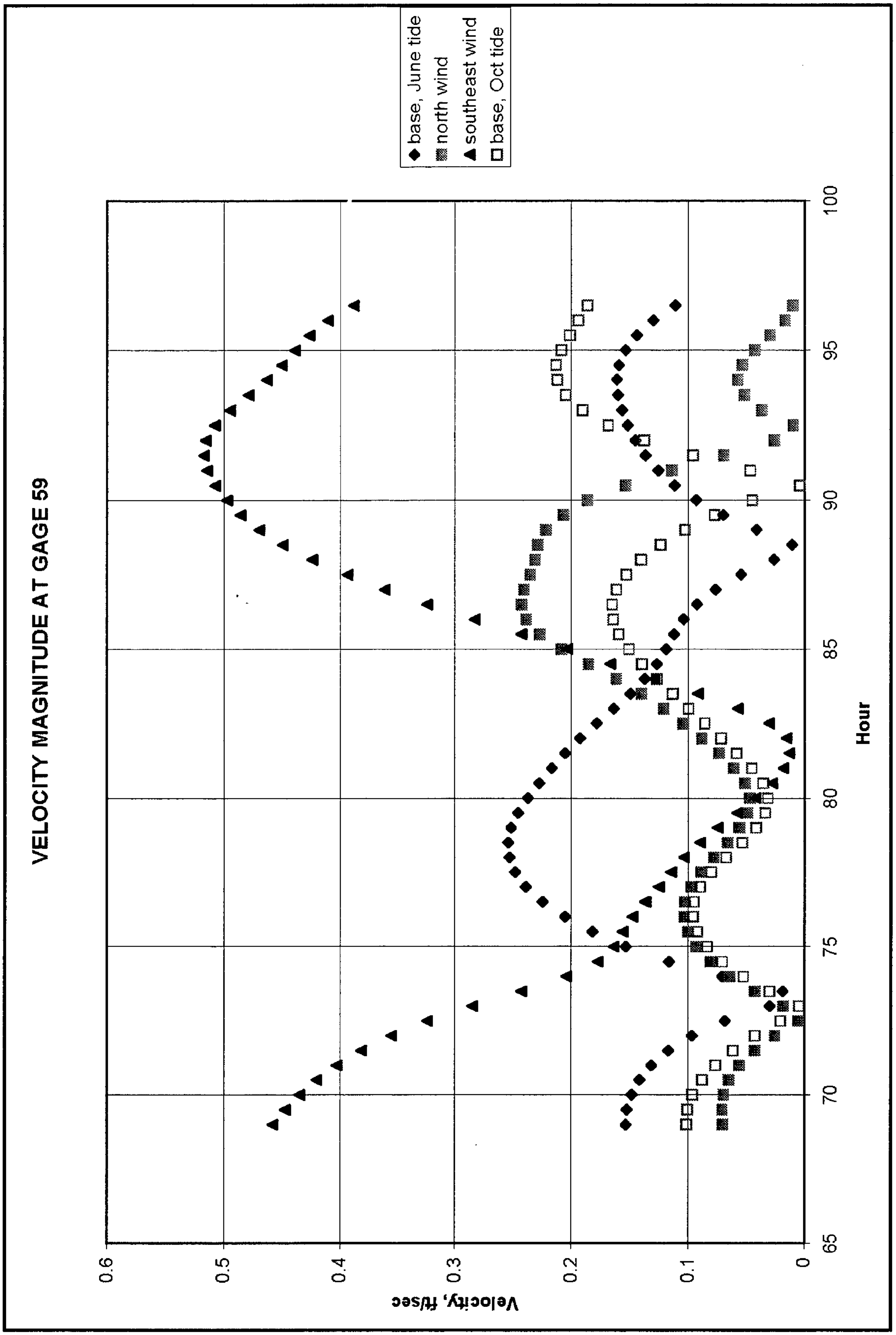
Appendix C
Numerical Model Results on Effect of Wind on Current Magnitude

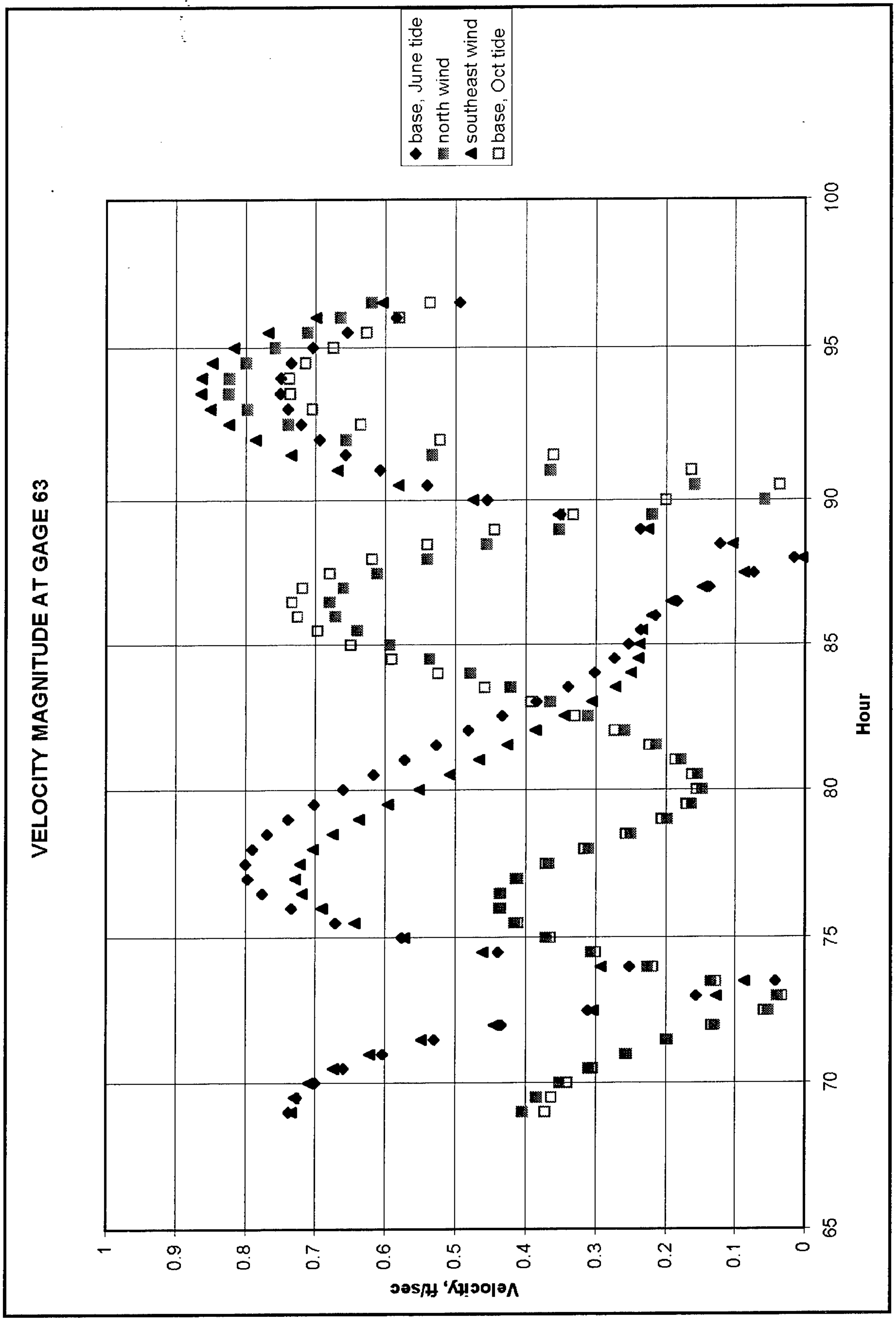


(To convert feet per second to meters per second, multiply by 0.3048)

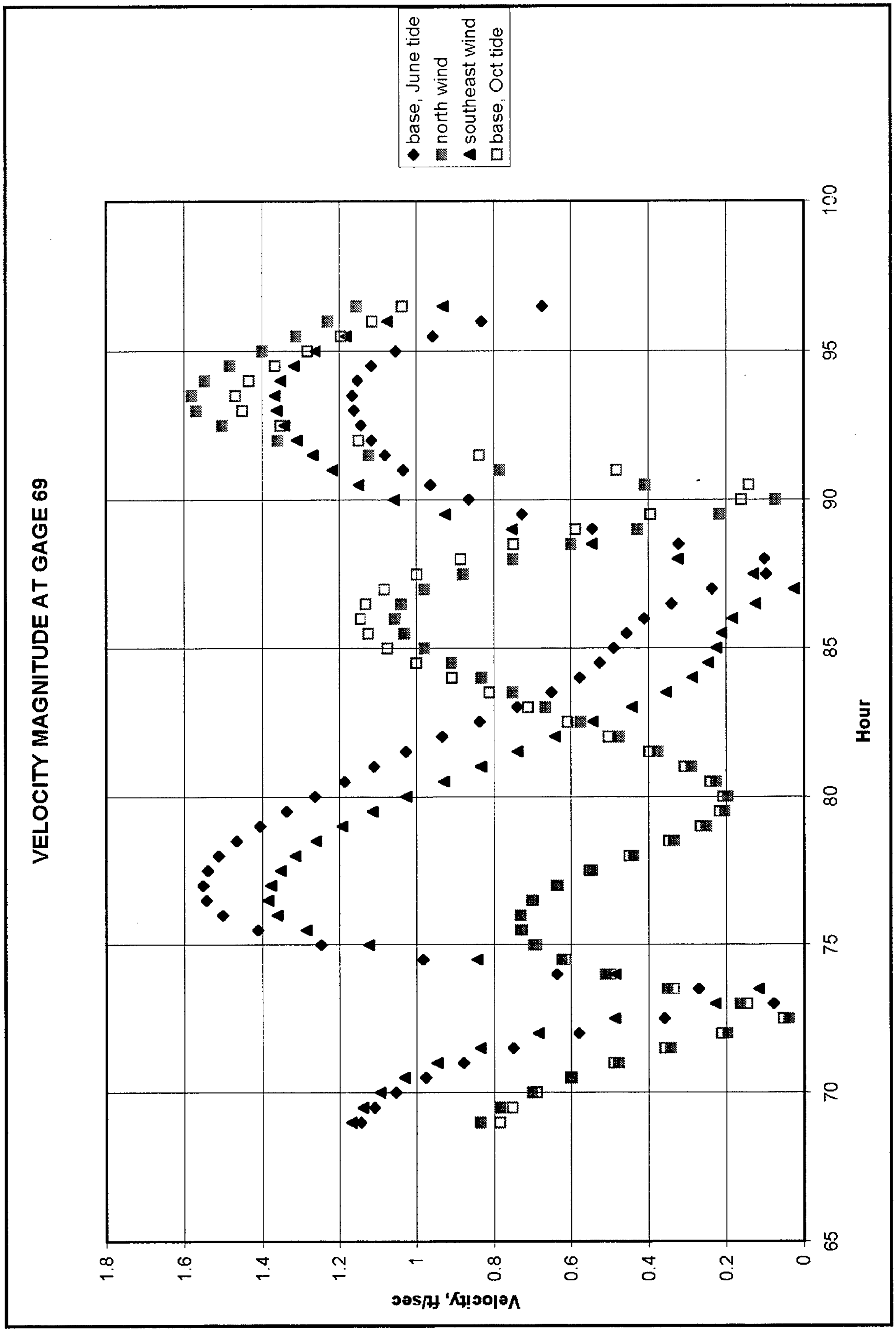

VELOCITY MAGNITUDE AT GAGE 55
base, June tide
north wind
southeast wind
base, Oct tide
Velocity, ft/sec
Hour
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
65
70
75
80
85
90
95
100

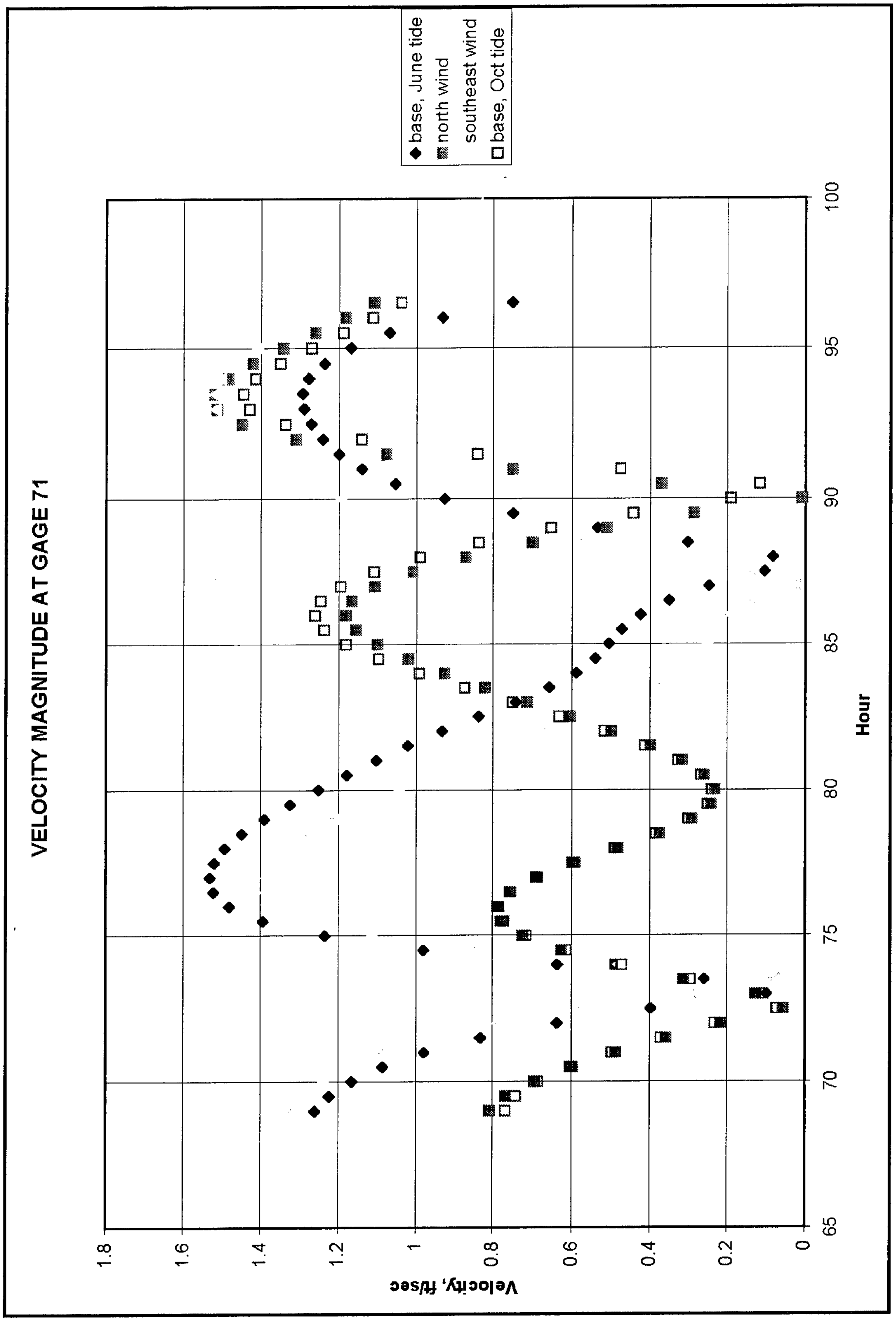

VELOCITY MAGNITUDE AT GAGE 57
base, June tide
north wind
southeast wind
base, Oct tide
Velocity, ft/sec
Hour
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
65
70
75
80
85
90
95
100

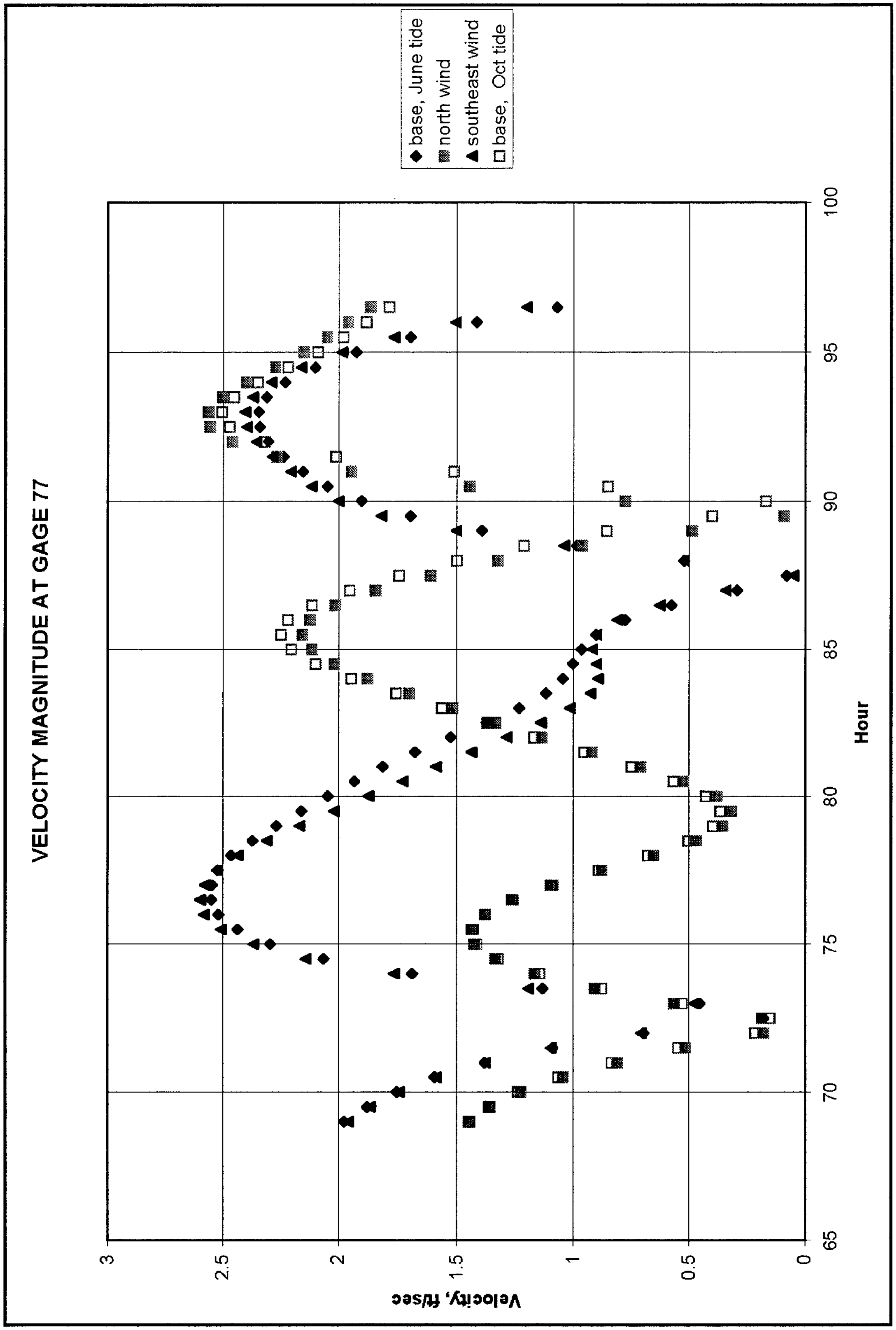

VELOCITY MAGNITUDE AT GAGE 59
Velocity, ft/sec
Hour
base, June tide
north wind
southeast wind
base, Oct tide
0
0.1
0.2
0.3
0.4
0.5
0.6
65
70
75
80
85
90
95
100

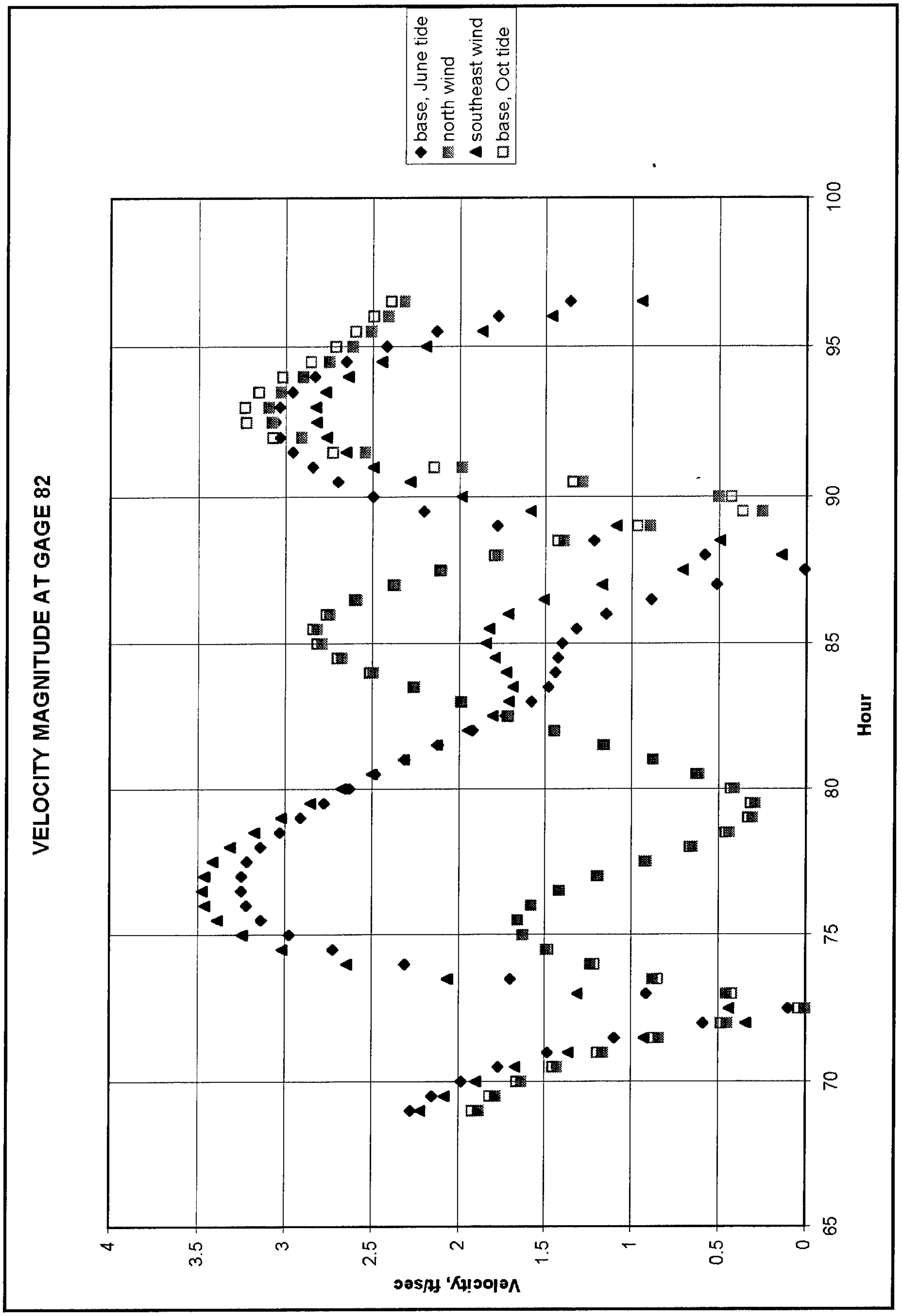


VELOCITY MAGNITUDE AT GAGE 63
base, June tide
north wind
southeast wind
base, Oct tide
Velocity, ft/sec
Hour
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
65
70
75
80
85
90
95
100

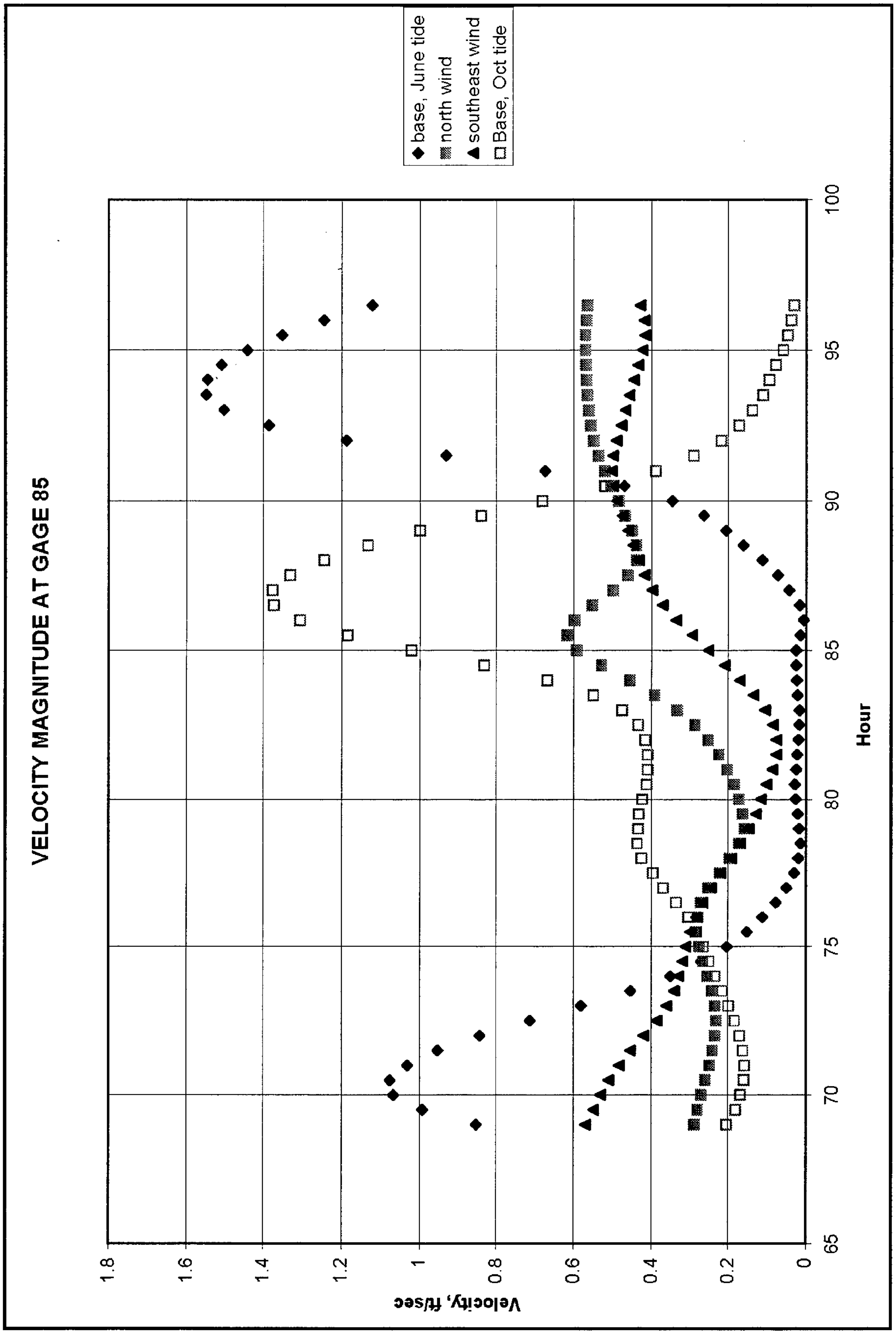

VELOCITY MAGNITUDE AT GAGE 69
Velocity, ft/sec
Hour
base, June tide
north wind
southeast wind
base, Oct tide
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
65
70
75
80
85
90
95
100


VELOCITY MAGNITUDE AT GAGE 71
base, June tide
north wind
southeast wind
base, Oct tide
Velocity, ft/sec
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Hour
65
70
75
80
85
90
95
100


VELOCITY MAGNITUDE AT GAGE 77
Velocity, ft/sec
Hour
base, June tide
north wind
southeast wind
base, Oct tide
0
0.5
1
1.5
2
2.5
3
65
70
75
80
85
90
95
100

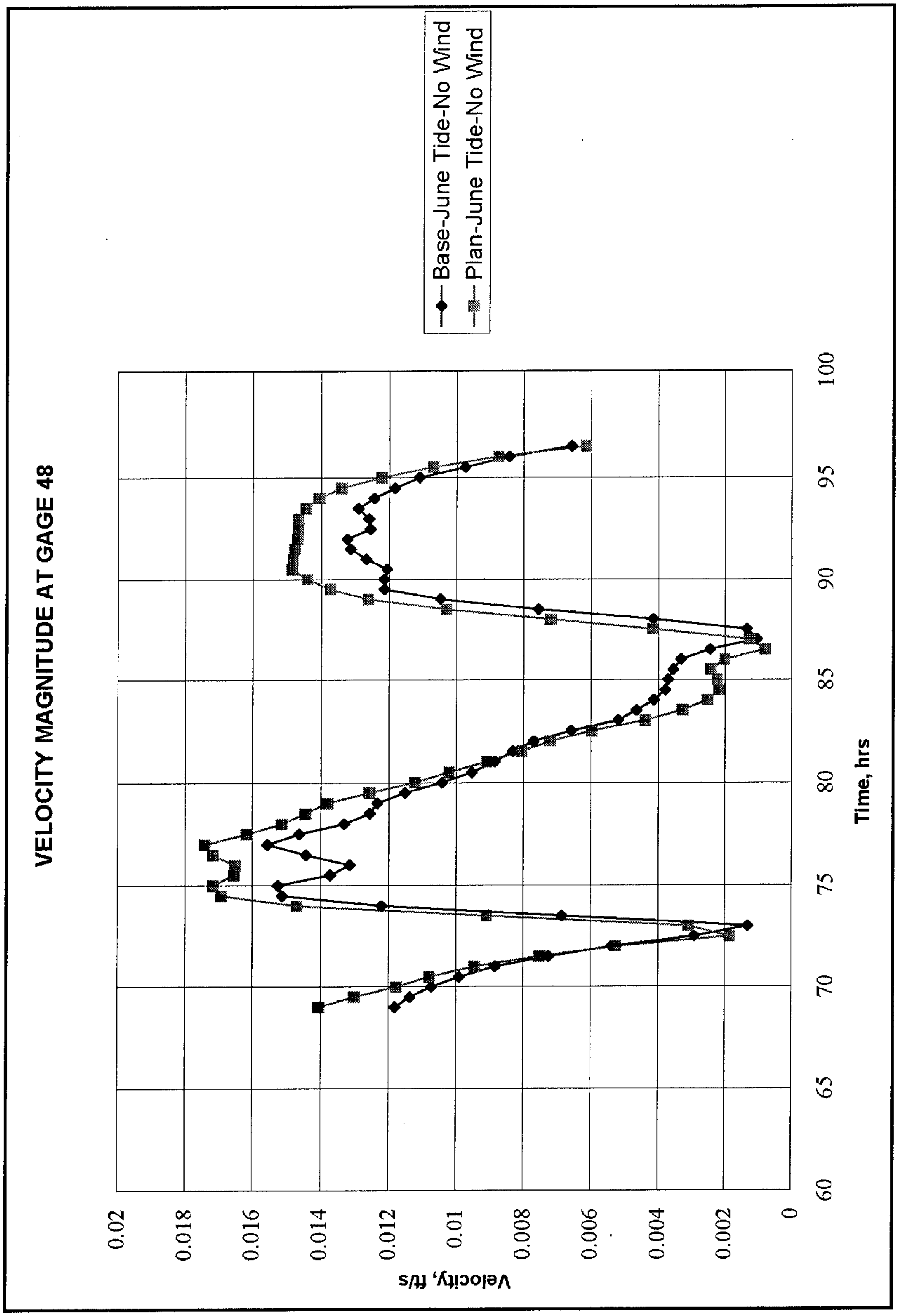


VELOCITY MAGNITUDE AT GAGE 82
Velocity, ft/sec
Hour
base, June tide
north wind
southeast wind
base, Oct tide
0
0.5
1
1.5
2
2.5
3
3.5
4
65
70
75
80
85
90
95
100

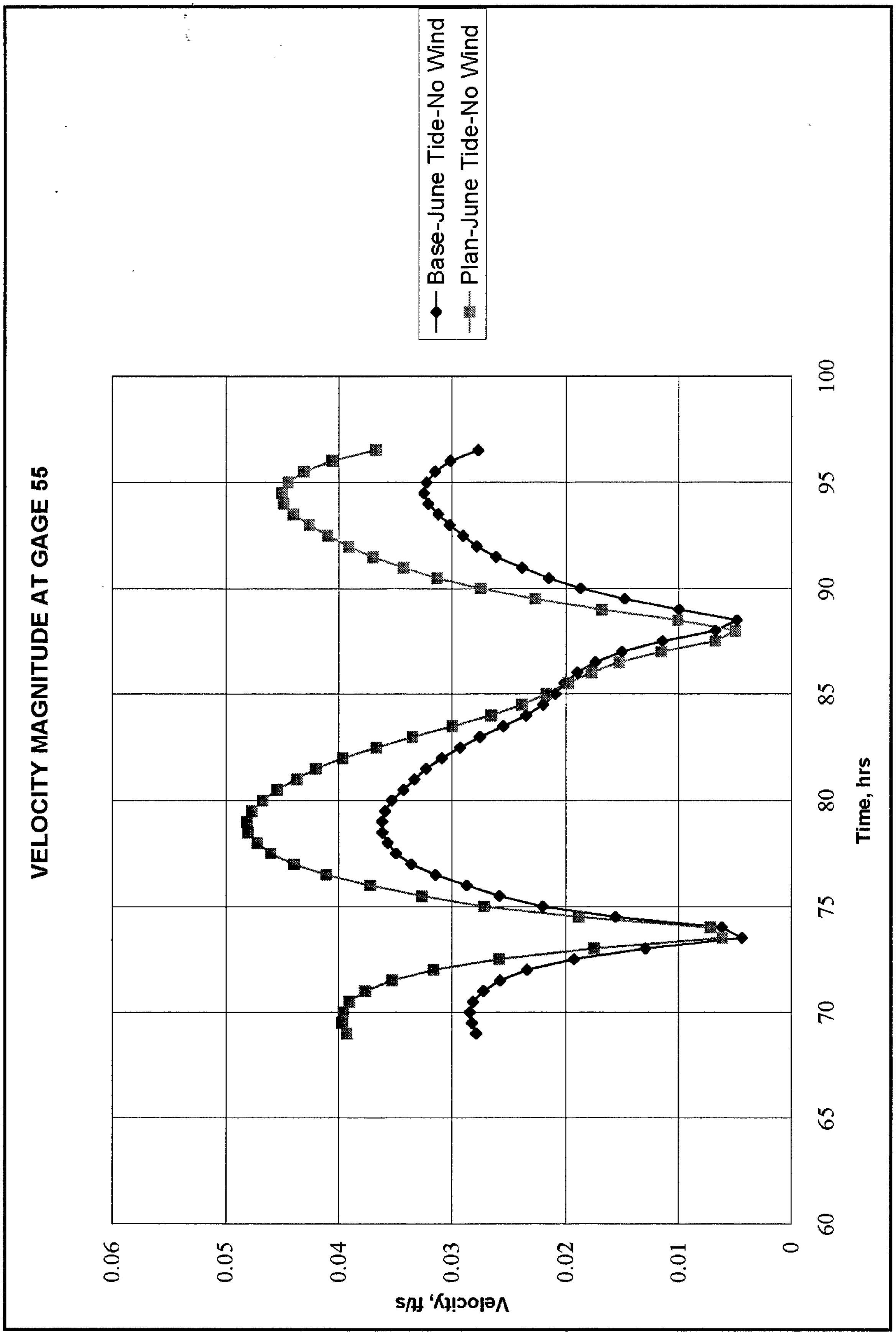


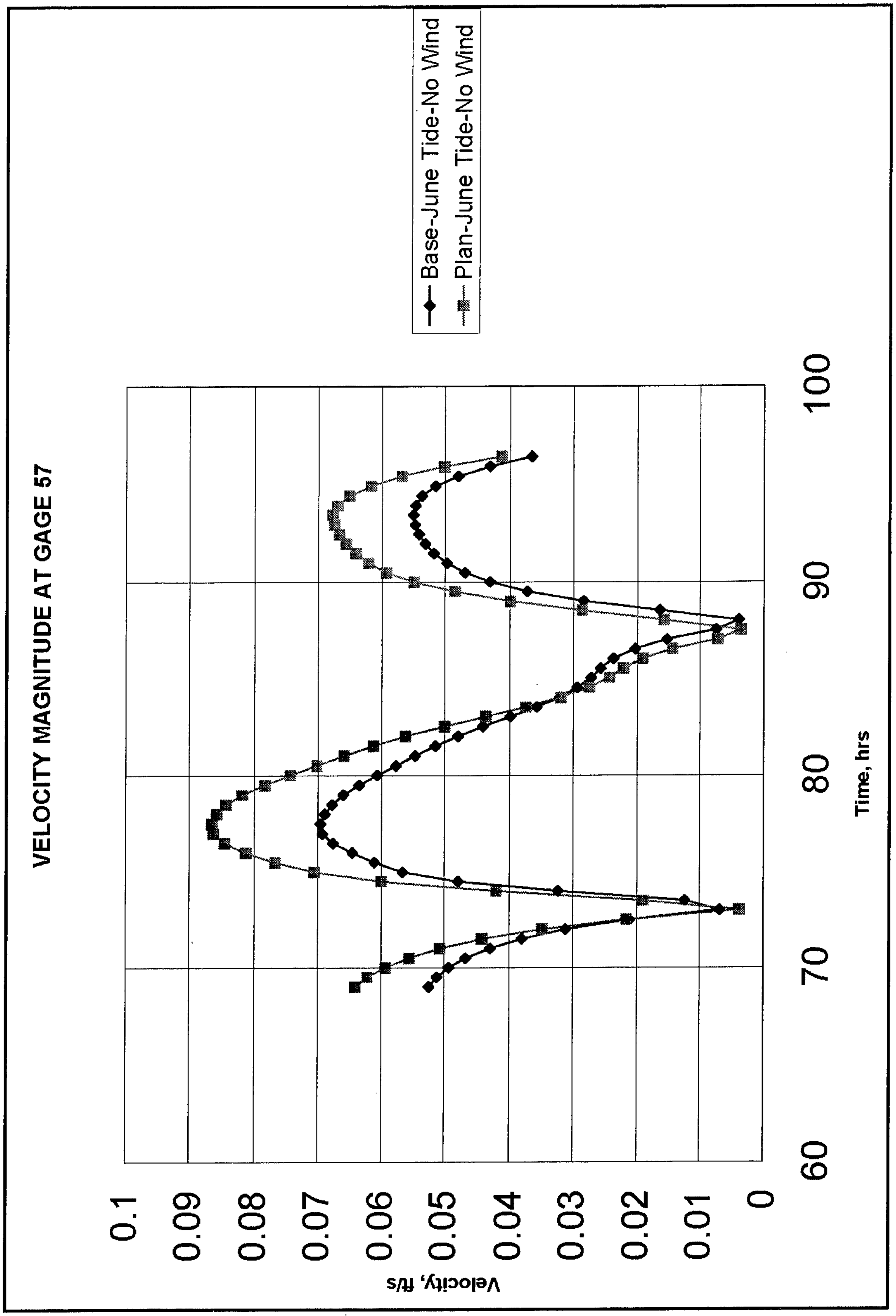
VELOCITY MAGNITUDE AT GAGE 85
base, June tide
north wind
southeast wind
Base, Oct tide
Velocity, ft/sec
Hour
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
65
70
75
80
85
90
95
100

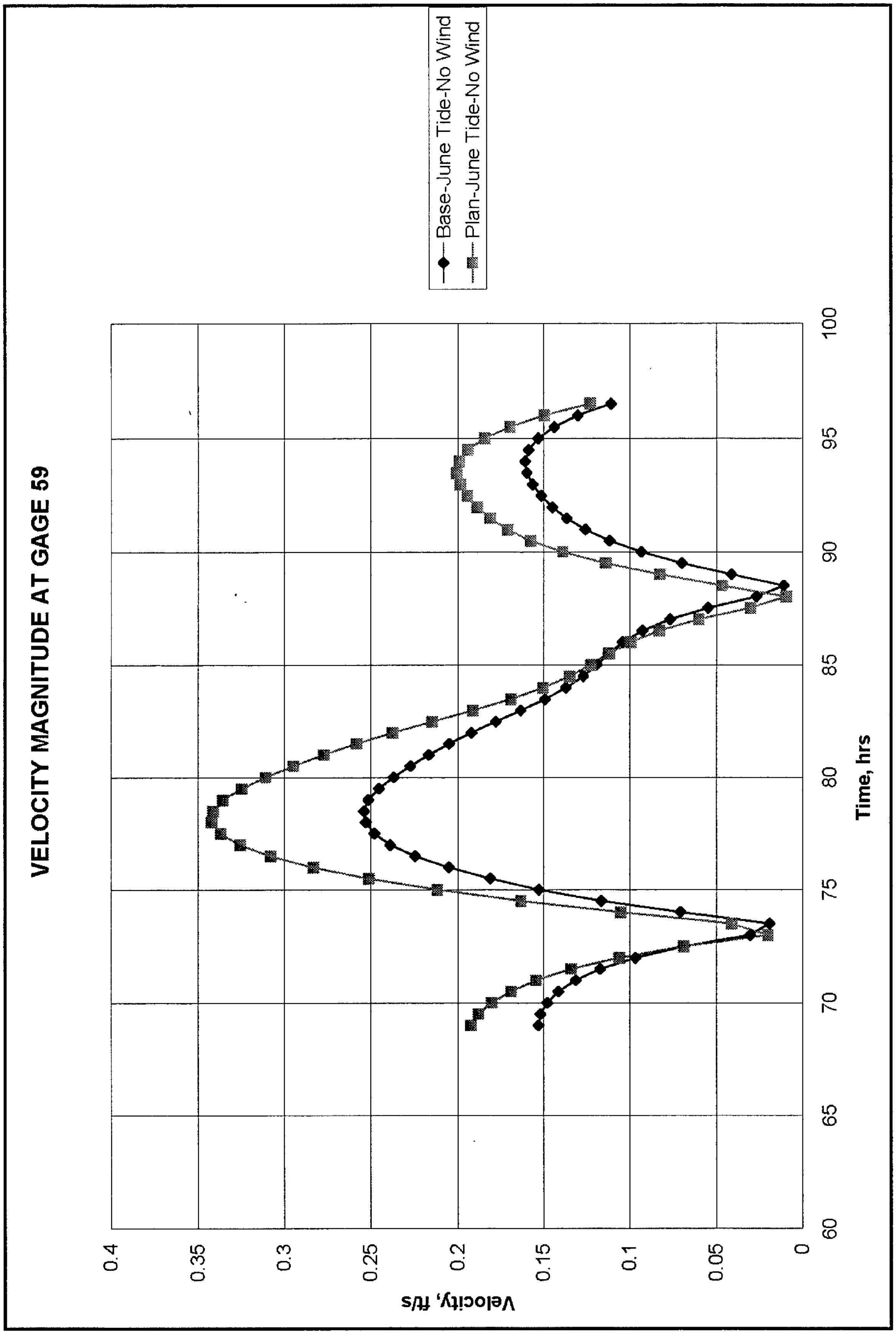
Appendix D
Numerical Model Results on Effect of Channel Deepening and Widening on Current Magnitude

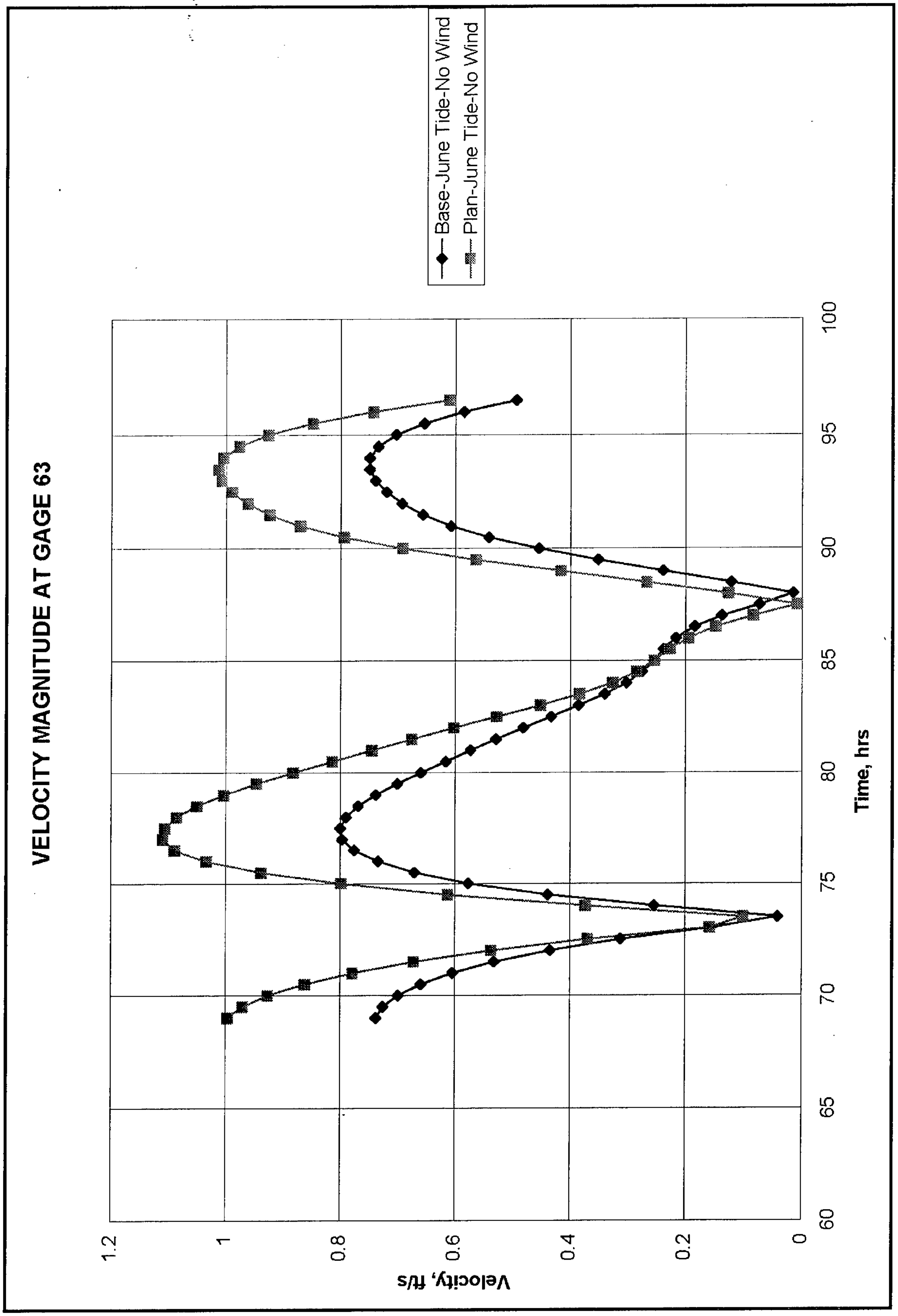


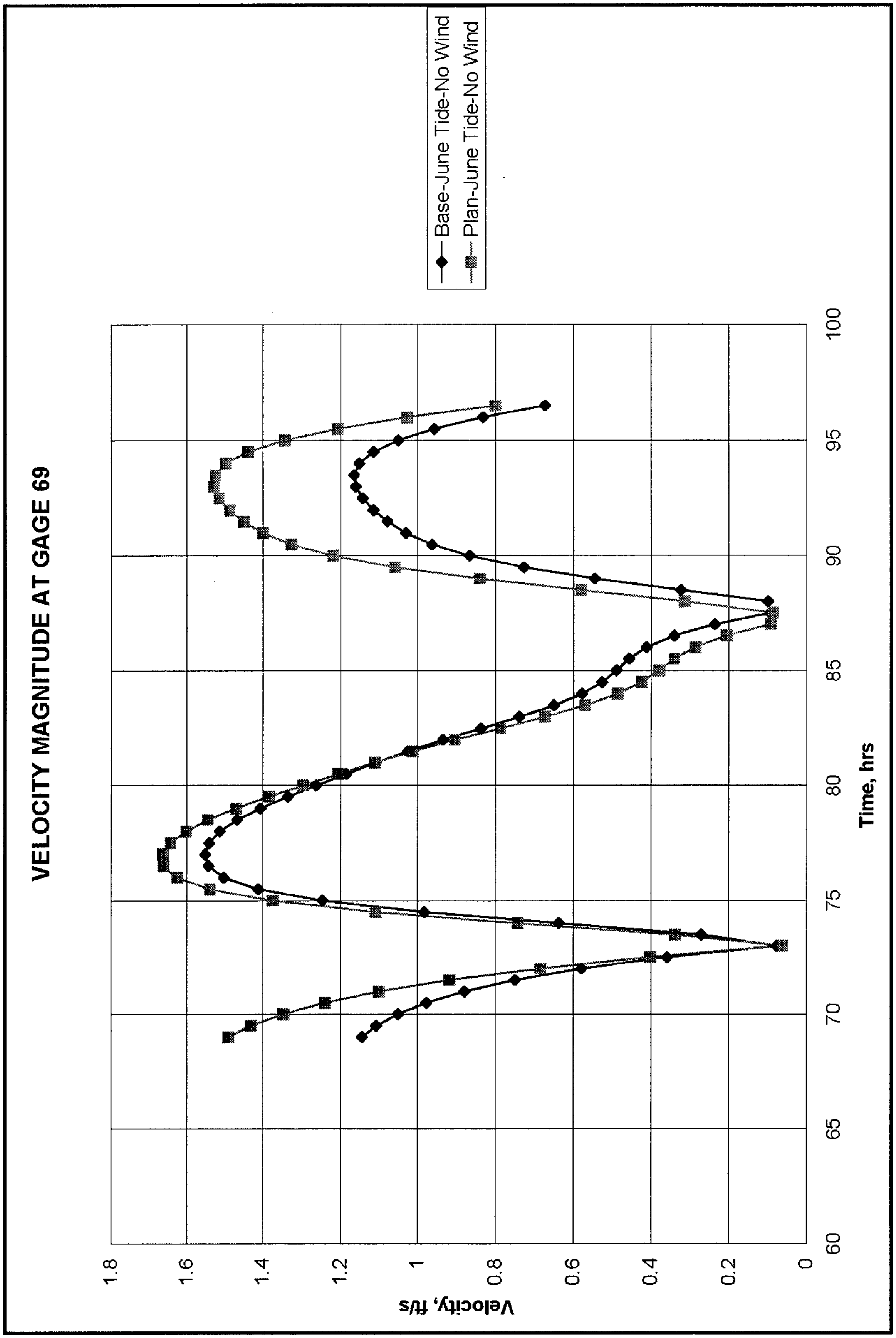
(To convert feet per second to meters per second, multiply by 0.3048)

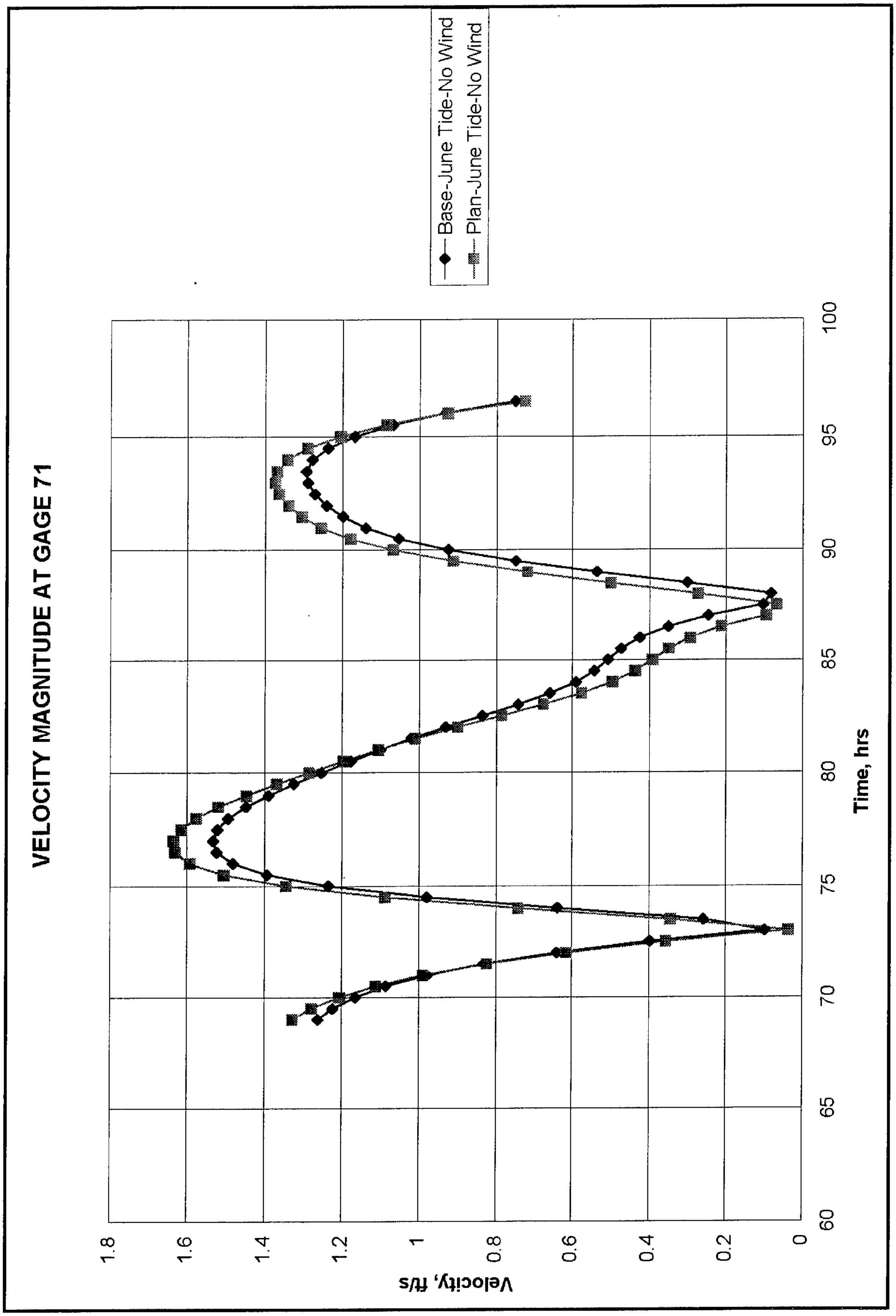

VELOCITY MAGNITUDE AT GAGE 55
Base-June Tide-No Wind
Plan-June Tide-No Wind
Velocity, ft/s
0.06
0.05
0.04
0.03
0.02
0.01
0
Time, hrs
60
65
70
75
80
85
90
95
100

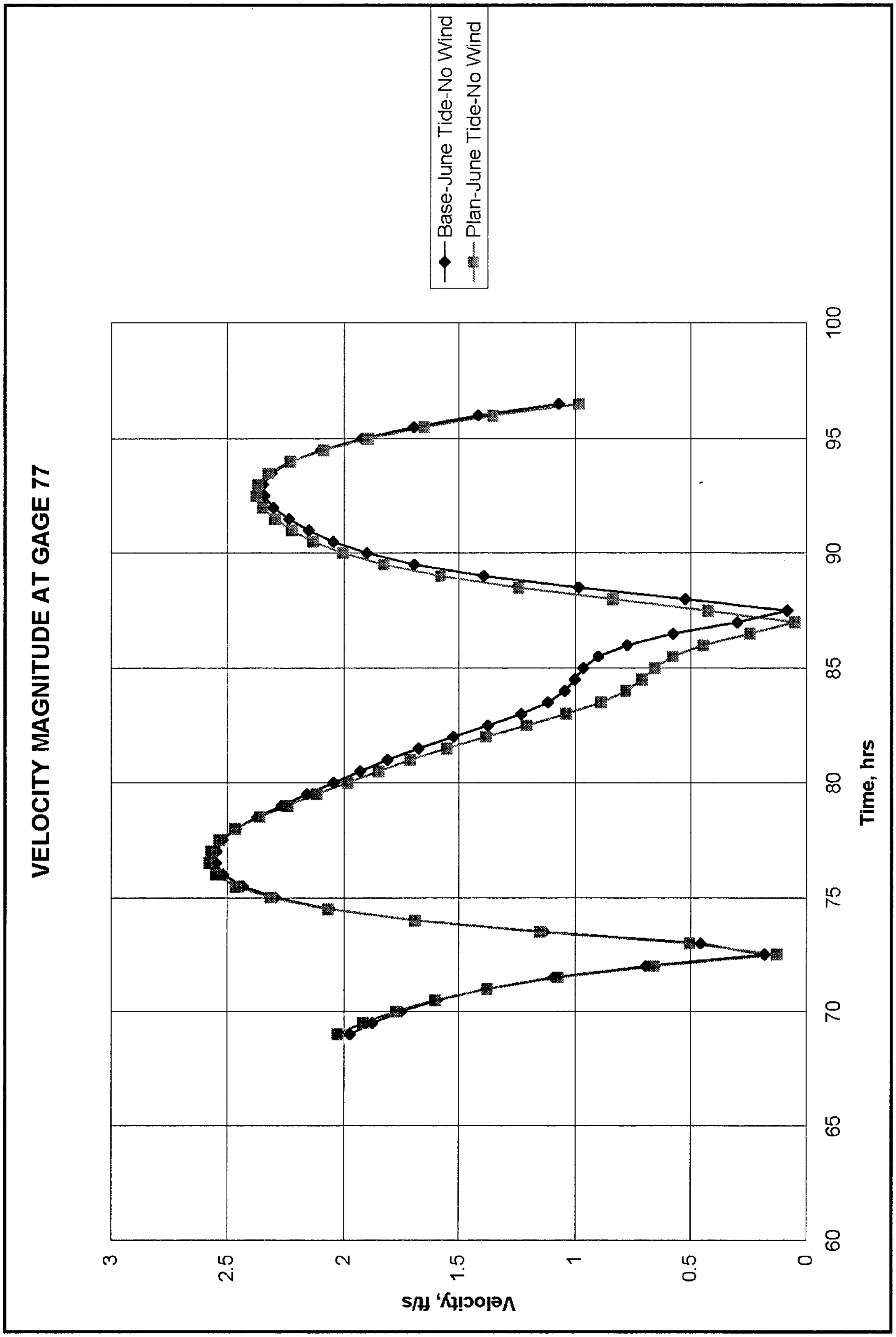

VELOCITY MAGNITUDE AT GAGE 57
Velocity, ft/s
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
60
70
80
90
100
Time, hrs
Base-June Tide-No Wind
Plan-June Tide-No Wind

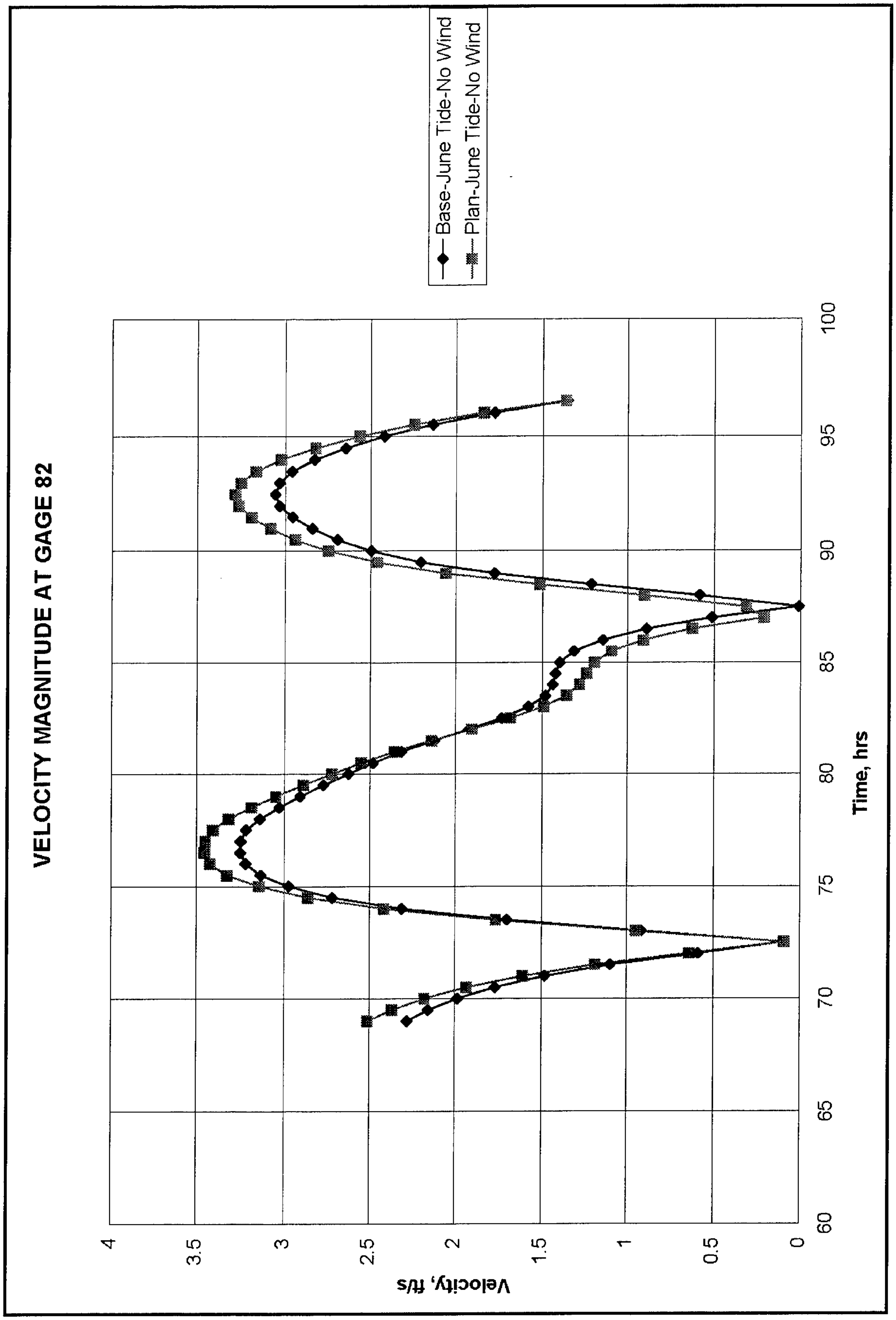

VELOCITY MAGNITUDE AT GAGE 59
Velocity, ft/s
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Time, hrs
60
65
70
75
80
85
90
95
100
Base-June Tide-No Wind
Plan-June Tide-No Wind

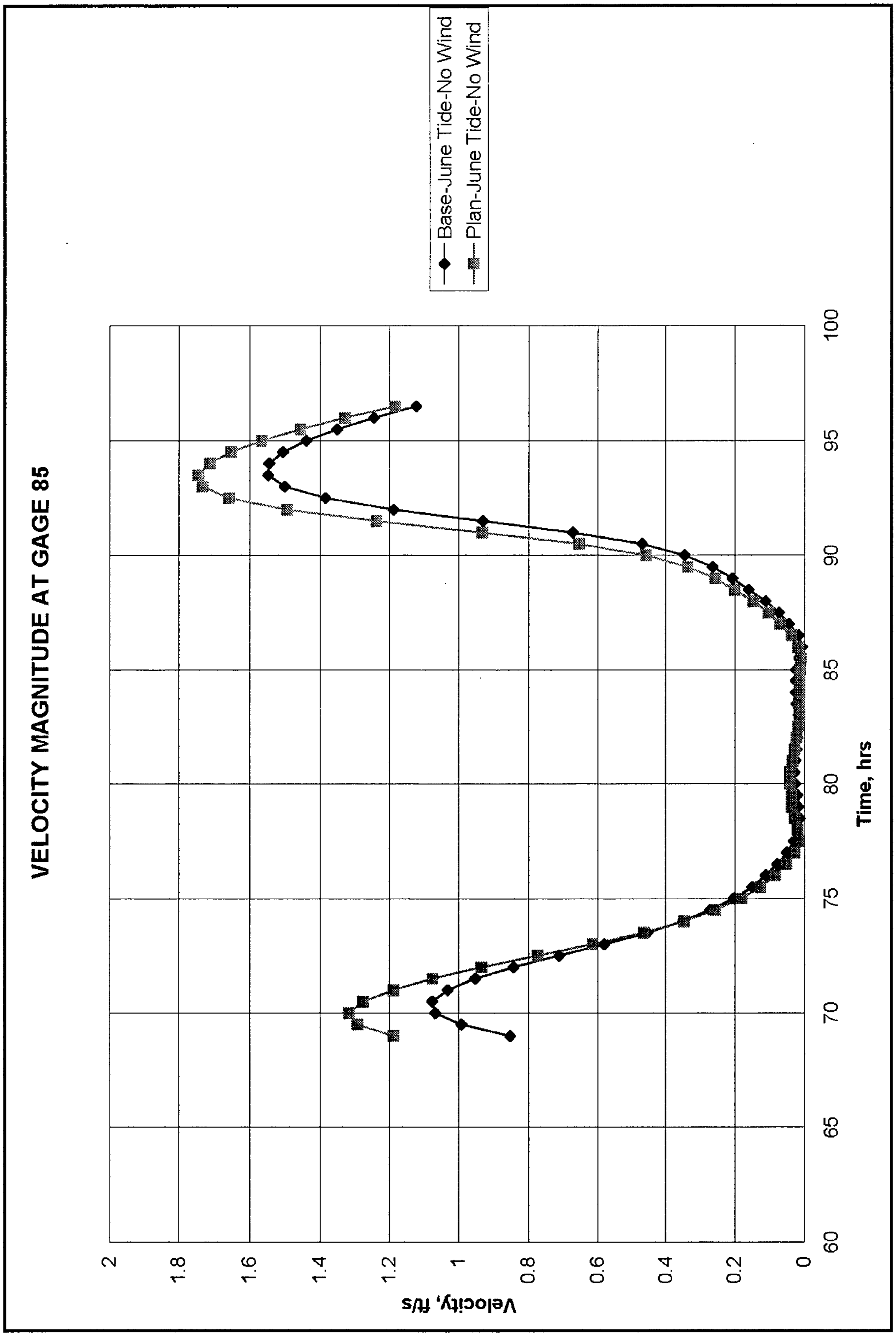

VELOCITY MAGNITUDE AT GAGE 63
Base-June Tide-No Wind
Plan-June Tide-No Wind
Velocity, ft/s
Time, hrs
0
0.2
0.4
0.6
0.8
1
1.2
60
65
70
75
80
85
90
95
100


VELOCITY MAGNITUDE AT GAGE 69
Velocity, ft/s
Time, hrs
Base-June Tide-No Wind
Plan-June Tide-No Wind
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
60
65
70
75
80
85
90
95
100


VELOCITY MAGNITUDE AT GAGE 71
Velocity, ft/s
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
60
65
70
75
80
85
90
95
100
Time, hrs
Base-June Tide-No Wind
Plan-June Tide-No Wind


VELOCITY MAGNITUDE AT GAGE 77
Velocity, ft/s
Time, hrs
0
0.5
1
1.5
2
2.5
3
60
65
70
75
80
85
90
95
100
Base-June Tide-No Wind
Plan-June Tide-No Wind


VELOCITY MAGNITUDE AT GAGE 82
Velocity, ft/s
Time, hrs
0
0.5
1
1.5
2
2.5
3
3.5
4
60
65
70
75
80
85
90
95
100
Base-June Tide-No Wind
Plan-June Tide-No Wind


VELOCITY MAGNITUDE AT GAGE 85
Velocity, ft/s
Time, hrs
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
60
65
70
75
80
85
90
95
100
Base-June Tide-No Wind
Plan-June Tide-No Wind

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE *(DD-MM-YYYY)*
November 2001

2. REPORT TYPE
Final report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Desktop Study for Shoaling Prediction in Corpus Christi Navigation Channel, Texas

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Trimbak M. Parchure, Soraya Sarruff, Ben Brown

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CHL TR-01-30

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Engineer District, Galveston
P.O. Box 1229
Galveston, TX 77553-1229

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The U.S. Army Engineer District, Galveston, has proposed deepening the Corpus Christi Navigation Channel from 13.7 m (45 ft) to 15.2 m (52 ft) from Gulf of Mexico to Viola Turning Basin in Inner Harbor and widening the channel across Corpus Christi Bay from 122 m (400 ft) to 152.4 m (500 ft). The Galveston District requested the U.S. Army Engineer Research and Development Center (ERDC) to conduct a desktop study on estimation of future shoaling in the deepened and widened Corpus Christi ship channel. The effect of adjacent disposal sites on channel shoaling needed to be included to estimate the amount of sediment from the disposal sites returning to the ship channel.

The approach for the desktop study consisted of analyzing new sediment data and already available field data on currents, historic shoaling/dredging records, and surveys. Assumptions were made on the spatial and temporal variation in the values of relevant parameters. Results were obtained by running the existing numerical hydrodynamic model for a few selected conditions to determine the effect of deepening the channel on the currents in the area of interest. The effect of wind was assessed. A quantitative estimate on future shoaling in the navigation channel was provided based on the field and model data analysis. A quantitative estimate of the amount of sediment from dredged material disposal sites transported back into the navigation channel was given.

(Continued)

15. SUBJECT TERMS

Corpus Christi Bay	Navigation Channel	Siltation estimate
Desktop study	Numerical hydrodynamic model	Texas ports
	Shoaling	

16. SECURITY CLASSIFICATION OF:

a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		134	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

14. (Concluded)

The conclusions of the study were: (a) The proposed deepening of the Corpus Christi navigation channel from 13.7 m (45 ft) to 15.2 m (52 ft) and widening of the bay channel from 122 m (400 ft) to 152.4 m (500 ft) would result in increasing the average annual total shoaling from the current 1.68 million cu m (2.2 million cu yd) to about 2.3 million cu m (3 million cu yd.); (b) It is estimated that about 30 percent of sediment deposited over the placement areas on the north and south sides of the navigation channel in the Corpus Christi Bay enters back into the navigation channel.